Photon

Issue 6

http://www.photonezine.com

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Solstices Are Milestones of Civilization

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Software for Telescope Control

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Editorial

Welcome to the sixth issue of **Photon**. As usual, my thanks go to all the contributors who took the time to send in material and photos for this issue.

Call for Submissions

As you've probably spotted, this issue is a couple of weeks late. That's down to a few factors, one being me suffering some bad health just after the New Year, another being due to having to devote time elsewhere and another being down to a low number of submissions for this issue, so I had to go hunting for writers.

You guys get a good ezine but, in order to provide that, I need you (some of you at least) to send in material, pictures and stories. While the ezine is free to download, nothing in life is really free, so as a form of payment, why not send in some material, however small. The closing date for Issue 7 is March 16th so you've over a month to put something together!

Comet Machholz Q2 has been in our skies for a few weeks now. Between the weather (it's been very cloudy this Winter) and bad timing - like having to be somewhere else when it does finally clear up, I haven't had a chance to see the comet. If you've taken any images of it, maybe you'd send them in so I can at least look at it vicariously.

You may know that I have a special interest in the Moon - that's the reason I put the LunarPhase Pro software package together. But, when time allows, I also like taking images of the Moon. The ezine cover and the Moon images in Showcase are images I took some time back. For those I used a dedicated CCD camera but I recently bought a Canon EOS Digital Rebel / 300D which I hope to try out soon with my 'scope. Phil Harrington's article in this issue describes the merits of such a camera for astronomical imaging and Tom Licha's article provides some thoughts on how to use such a camera for astrophotography. I'll be setting up a page on the Canon EOS 300D at the Night Sky Observer site over the coming weeks, so keep an eye out if you're interested.

Rod Mollise reviews some freeware software that's used for controlling a goto telescope and Tom Nicolaides describes how he motorized his own 'scope. Ever thought about collecting meteorites? Mark Bostick describes the Sikhote-Alin fall - these meteorites are one of the easiest to acquire to start a collection. One of their big cousins impacted in Canada a couple of billion years ago to form the Sudbury Crater. In the first of a two-part article, Charles O'Dale provides some research on the crater. Tim Carr's Great Astronomers is back, with a look at Isaac Newton. Von Del Chamberlain looks at how the Summer Solstice has been perceived by previous cultures and Anthony Murphy continues his analysis of astronomy at the megalithic sites in Ireland's Boyne Valley. George Reynolds also reviews some reading material.

Don't forget that the ezine contains hot-links (underlined blue text) to external websites so, to get the most out of it, it's better if you're online when reading it. The links take you to websites that provide background information on the subject or to definitions of unfamiliar terms or detailed descriptions of ideas portrayed in the text.

As ever, the ezine is peppered with little anecdotes and short story items. If you've come across any or something has happened personally to you, please let me know. If you'd like to remain anonymous - that can be arranged!

Night Sky Observer News

As you probably know, I run the Night Sky Observer website. I recently expanded the Moon Pages at the site and the single large page that was there has been broken out into several faster loading ones.
With the ESA's recent Huygens probe landing on Titan, I've also added some pages dedicated to Saturn and the Cassini/Huggens mission.

LunarPhase Pro News

If you are a LunarPhase Pro user, V2.16 was released in early Dec. 2004. If you're not already using this version and you are using a V2.xx release of the software, you can download V2.16 via the ***Check for Upgrade*** button on the About screen. This release fixes a couple of minor bugs. V1.xx users can upgrade to Version 2 at http://www.lunarphasepro.com/support

JupSat Pro News

V1.40 of JupSat Pro was released in early Feb. 2005. This version fixes a few bugs and adds printing to the Great Red Spot Transit Times and Satellite Tracks screens. Existing users can download the upgrade from the JupSat Pro page.

Moon Calendar News

The 2005 Daily Moon Phase Calendar I put together is now available at a 25% discount. There aren't many left.

Gary Nugent
photonmag@excite.com
http://www.nightskyobserver.com

For up-to-date news on astronomy and space:
The Night Sky Observer

Book Review

By George Reynolds

[Deep-Sky Wonders](#) by Walter Scott Houston
With selections and commentary by Stephen James O'Meara
ISBN:

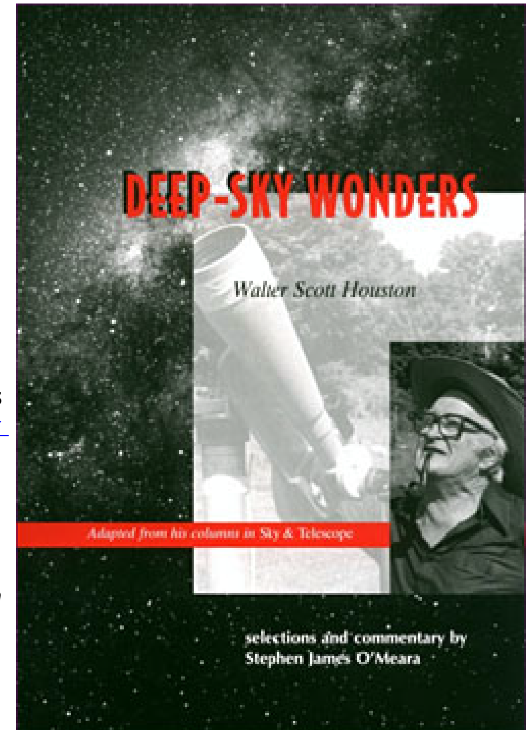
Walter Scott Houston was a dedicated amateur astronomer whose monthly column, "Deep-Sky Wonders" appeared in *Sky & Telescope* magazine for almost 48 years, from 1946 to 1994. Though he passed away in 1993, his writings live on to educate and inspire both new and old generations of stargazers. Noted amateur astronomer and author Stephen James O'Meara compiled Scotty's monthly columns and edited them into book form, *Deep-Sky Wonders* (1999, Sky Publishing Corp.).

There is a chapter for every month of the year, with Scotty's engaging descriptions of the objects and how to find them. Many are challenging, with a brightness of 10-11 magntiude or less. Each chapter begins with O'Meara's personal comments and ends with a table of that month's objects, in ascending order by M- and NGC- number, showing the type of object, its RA and Dec, and page and chart numbers in the *Millennium Star Atlas*, *Uranometria 2000.0* and *Sky Atlas 2000.0.*

Scotty blazed trails in amateur astronomy, never content with the status quo. This book illustrates his spirit for seeking out elusive objects and his love for the wonders of the heavens. He often asked readers of his column to submit their comments and observations. Many of those observations are recounted in this book. Scotty was a master, with vast knowledge of the realm of space, but was ever down-to-earth in his discussions with his readers. In the pages of this book you will find friendly, familiar Messier objects and exotic, hard-to-find challenge objects, all skillfully described in Scotty's own words, with anecdotes on how he came to see them.

O'Meara's preface to the book explains his relationship with Scotty on the *S&T* staff and as editor of Scotty's column in the 1990s. O'Meara idolized Walter Scott Houston, and attempts in his own books to emulate the nearly-poetic writing Scotty was famous for. Two other well-known astronomy figures, Brian Skiff and Dennis DiCicco added their comments in forewords to the book.

But Scotty's own colorful words make up the bulk of *[Deep-Sky Wonders](#)*; here is a long passage from the first page of chapter one, "January":



"*I learned my constellations in Tippecanoe, Wisconsin, a town that long ago vanished into the urban sprawl of Milwaukee. Back then Tippecanoe was a rather treeless tract of farmland bounded by the great clay bluffs of western Lake Michigan. The sky ran right down to the horizon and, with an almost irresistible force, called for you to look at it. In January 1926, after a midnight walk home from ice-skating, I wrote:*

'Snow crystals sparkle like blue diamonds, but with a dreamy gentle radiance totally unlike the harsh gem. A rail fence as black as Pluto himself runs along the road. The forest is black in the distance. The landscape is a masterpiece in ultramarine and sable.

'As if in contrast, the heavens above blaze with a thousand tints. Incredible Orion leads the hosts with blue Rigel, ruby Betelgeuse, and bright Bellatrix. His silver belt and sword flash like burnished stellar steel. And more advanced is dark and somber Aldebaran, so heavy and gloomy. In fitting contrast are the delicate Pleiades, who sparkle "like a swarm of fire-flies tangled in a silver braid".

'How can a person ever forget the scene, the glory of a thousand stars in a thousand hues, the radiant heavens and the peaceful Earth? There is nothing else like it. It may well be beauty in its purest form.' "*

*(Scotty referred to a stanza in the poem *Locksley Hall* by Alfred Lord Tennyson.)

Get the book, *Deep-Sky Wonders*, and get to know Walter Scott Houston. Let him inspire you with his timeless message to get out under the stars. Enjoy reading the book on cloudy nights, and use its lists on clear ones.

ROBOSCOPING!

By Tom Nicolaides

I've been interested in Astronomy since I was a little kid. At the age of 8 my dad bought me a Gilbert 2.5 inch reflecting telescope. I couldn't see a whole lot through it, but I could see craters on the moon and the moons of Jupiter. I was hooked. In high school I got a [Criterion RV-6]() six inch reflector. I could certainly see a lot more than with the old Gilbert (a toy). In college I got a job with the physics department and operated their observatory for the general public. It was a pretty good scope – a 6 inch f/15 refractor – and this was long before the commonly available refractors of today. Even from the light-polluted city of [New Orleans](), I could show visitors Venus, Jupiter, Saturn, Mars, the Moon and some deep space objects such as M31, M57 and open clusters.

Upon graduation I got married, raised a family and while I didn't lose interest in astronomy, I was not active. Occasionally I'd pick up a [Sky and Telescope]() magazine and look at the new developments and advertisements.

Well, my family is grown now and a couple of years ago I purchased an [Orion Astroview 120mm]() refractor on a German equatorial mount with manual slow motion controls. I wouldn't say I was disappointed with the scope – it gave fine views – particularly of the moon and planets open star clusters and brighter nebulae. The problem was I was spending more time hunting deep space objects than actually looking at them. So I'd get my new Sky & Telescope magazine, read about the Deep Sky Objects (DSOs) that were visible and not take out the scope because of all the effort in finding these astronomical wonders.

Right Ascension Motor

Not long after, I was scanning eBay listings and I came across a motorized Meade mount. It didn't have "Go-To" capability, but the seller assured me that with the addition of Meade's Autostar hand paddle it could be made to be so. So I bid on the mount, won the auction and it arrived. First thing I found was the mount was vastly undersized for the Orion OTA. However, I did mount it in the cradle and took it out. It was fun pressing the buttons and having the OTA move. But it was no easier to find anything and there was no sidereal tracking to keep the object in view once I did find it. I later learned that was a mount from Meade's lower end scopes and wasn't well-thought of by serious amateur astronomers. Still, I went ahead and found a used Meade Autostar 495, ordered it and hooked it up.

With excitement I took the scope out first clear night. I followed the instructions for alignment and amazingly it worked – sort of. That is, I could tell it to go to objects that were fairly bright and it would bring me reasonably close

Declination Motor – showing high-tech duct tape

View showing RA and Declination Motor mounts

– within a few degrees. But I could tell that on dim telescopic objects it wouldn't be accurate enough. Also, that inexpensive Meade mount was seriously unstable with the Orion OTA. Focusing was difficult at high power – too shaky. I needed to improve it.

I started to do some web searching and I found a pile of web sites devoted to converting telescopes to go-to operation using Meade parts. Some of the methods involved using the motors from the mount I got off of eBay, the Meade Autostar paddle and a good German equatorial mount. For this information I need to thank Mike Weasner, Chris Erickson, Steve Bedair, Peter Vasey and many others. I discovered several ways of attaching those Meade motors to my mount. I selected a method that involved machining a coupler to the worm adjustment shaft on my Right Ascension and Declination shafts. Enlisting the help of a machinist friend of mine we went to work one Sunday morning and by late that evening we had a pair of couplers that fit right onto the mount. Then I discovered that in certain configurations the motors clashed with each other. Clearly modifications were in order. So I kept the coupler for the RA shaft and made a new one out of right angle aluminum and duct tape and fastened it onto the declination axis.

Well, Success! The motors turned the axes easily. That's about the time I discovered the Autostar 495 hand paddle doesn't know about German Equatorial Mounts – Alt-Az mounts only! However, I learned that Dick Seymour has patched Autostar firmware to include GEM type mounts, but I would need Meade's Autostar firmware loader and a cable. On Mike Weasner's site I found the schematic for the necessary cable. From Meade I got the Autostar firmware loader. From Radio Shack I got the parts necessary to make an RS-232 cable that connects to the Autostar. From Dick Seymour (via Weasner's site) I got the patches and new firmware.

Me and my Roboscope!

I ran the firmware loader and had no trouble getting the new firmware into the Autostar. The interesting thing is that for all practical purposes I now have Meade's more expensive 497 hand paddle - All by doing a firmware update. Upon loading, I found various types of GEM type telescopes listed. I selected one and tried doing an alignment that night. The setup didn't even come close to finding the alignment stars – half the time the scope ended up pointed at the ground. So some more research was in order. That's when I found Peter Vasey's site. He converted a mount almost identical to mine. I learned that Autostar assumes a default gear ratio on the worm drive. Autostar was expecting 100 teeth on the worm gear. According to Peter I had 65 on declination and 130 on RA. Autostar provides a place in their menu to input new ratios. The Meade manual warns the user never to change these numbers. So change them I did, to the numbers Peter had listed on his site. The scope still pointed towards the ground. Hmmmmm...something else, then? On Bedair's site I found a more comprehensive explanation of gear ratios. It turns out that the sign is significant. That is, plus or minus. He states that if the telescope turns backwards, the sign is probably wrong. Could that be it? Two numbers mean four possibilities on signing. ++, +-, -+, or --. I tried ++ already, so I switched to + declination and – RA. No better. Okay, then we'll make both negative. Still didn't work. That left negative for Declination and Positive for RA. I tried alignment one last time. The Autostar told me it was selecting Vega for alignment. I felt immensely satisfied when the scope smoothly slewed over to the direction of Vega and placed it into the field of view of my finder. With growing excitement I centered Vega, hit OK and the scope told me it was using Deneb as the next alignment star. The scope moved, I looked into the finder and there it was, almost dead center. I hit OK, the Autostar said CALCULATING and then ALIGNMNET SUCCESSFUL. Wow!

The Autostar then switched over to OBJECT mode in which I could select things to look at. Since I was already in the area I selected M57, the Ring Nebula. I knew how to find it myself and I always liked looking at it. I told Autostar to take me there and without even looking in the finder it placed it in the FOV of an EP that gave me 66x. It was an amazing feeling. It felt like I'd discovered M57 myself!

I tried a lot of other objects that evening. In that one night I saw more DSOs than I saw during all the time I was active in astronomy combined. It has greatly increased the pleasure of observing.

That's not to say there were no problems. In trying to improve performance I went through a procedure to "train" the drive – Not only did it make pointing worse, through a bug in Meade's firmware it made it almost impossible to center an object. But with the online help available I was able to conquer the "rubber banding" effect, as it's called.

I've since bought other Meade motors and just completed converting another mount to Go-To operation. The enjoyment of being able to observe using Go-To, coupled with the deep satisfaction of using equipment that I built and modified myself has vastly increased my enjoyment of our hobby. Now I go out almost every clear night.

Tom Nicolaides is a propulsion test engineer for NASA and lives on a small farm under fairly dark skies in Southern Mississippi in the USA. The goats, horses and donkeys like to stargaze with him.

Useful Links

Yahoo Roboscope group:
http://groups.yahoo.com/group/RoboScope/
Chris Erickson's Conversion Site:
http://www.data-plumber.com/autostarupgrade.htm
Steve Bedair's site:
http://bedair.org/ScopeStuff.html
Peter Vasey's conversion site for the EQ3-2
http://mysite.wanadoo-members.co.uk/equipnbits/EQ3.htm
Weasner's Autostar Information
http://www.weasner.com/etx/autostar_info.html

Relativity Explained!

Albert Einstein was often asked to explain the general theory of relativity. "Put your hand on a hot stove for a minute, and it seems like an hour," he once declared. "Sit with a pretty girl for an hour, and it seems like a minute. That's relativity!"

A Universal Notion?

Albert Einstein once attended a scientific conference at which an eminent astronomer declared that "to an astronomer, man is nothing more than an insignificant dot in an infinite universe." "I have often felt that," Einstein replied. "But then I realize that the insignificant dot who is man is also the astronomer."

Cosmic Blooper

Shortly after the publication of Albert Einstein's general theory of relativity (in 1915), Alexander Friedmann (a Russian mathematician) was surprised to discover that Einstein had failed to notice a remarkable prediction made by his equations: that the universe is expanding (a prediction later confirmed by observations made by Edwin Hubble in the 1920s).

The cause of Einstein's oversight? He had, incredibly, made an elementary error in his calculations: In effect, he had divided by zero (a cardinal sin in mathematics)!

the ancient astronomers of newgrange

By Anthony Murphy

Knowth

From [Dowth](), the Place of Darkness where the Winter sun sets, we must now turn our attention to the third great Brugh na Boinne mound, Knowth, which has in recent years been causing great excitement in the fields of both archaeology and astronomy. In the 1960s, Knowth was just a large mound in a field, with no sign of any stones visible. Since then, under the direction of Professor George Eogan, the whole site has been thoroughly excavated and has thrown up more than its fair share of treasures, decorated stones, surprises and mysteries.

Probably the biggest reason Knowth has caused such a sensation is its plethora of megalithic art. The site contains well over a quarter of all megalithic art known to exist in Europe, and many of its 127 kerbstones are decorated, some highly so. Knowth also has two passages, facing east and west. In our astronomical exploration of Knowth, we first turn to one of the most exciting stones in the Boyne Valley - the kerbstone which was named the "Calendar Stone" by Martin Brennan.

The Great Mound at Knowth

Illustration of the "Calendar Stone" kerbstone

This kerbstone at Knowth proves that the people of the Neolithic were competent astronomers, who had made observations over great periods of time, and were able to pass on their astronomical knowledge from generation to generation. The Lunar Stone presents a format that can be used to track the synodic month, and from it we can obtain very important calculations of large subunits of the Lunar, or "Metonic", Cycle.

What this stone demonstrates is that the Neolithic people who constructed the mound were aware that the solar year, which is 365 days long, does not contain an equal number of synodic periods of the Moon. But it also shows they were aware of the great 19-year Lunar Cycle and studied the movements of the moon over long periods of time.

A synodic period of the Moon is marked by the return of the Moon to the same phase, and is exactly 29.531 days long. So therefore, 12 lunar months, or 'Synodic

months' is exactly 354.372 days long. But this is a whole 11 days shorter than a tropical year. The Neolithic mound-builders knew this, and used the Lunar Stone to record their calculations of the numbers of synodic lunar months in tropical years. 25 synodic months is 738.275 days, which is 8 days longer than 2 tropical yrs.

- 37 synodic months is 1092.647 days, 3 days short of 3 tropical years.
- 49 synodic months is 14 days shorter than 4 tropical years.
- 62 synodic months is 5 days longer than 5 tropical years.

The Lunar Stone at Knowth, pictured on the evening of Autumn Equinox, Sept. 22nd, 2000

It is this value in the sequence which is represented on the lunar stone at Knowth. There are a total of 31 'waves' across the stone, surrounded by representations of the Moon - 29 of them - representing the 29 days of the synodic lunar month. If we double the number of waves, we get 62, representing 62 synodic periods of the Moon, which, as we have already seen, is just 5 days longer than 5 tropical years. The sequence continues until we get a very close correlation between synodic months and tropical years: 99 synodic lunar months is only 2 days longer then 8 tropical years. But even closer still is 136 synodic months, which ends about a day before 11 tropical years. And if we add 99 synodic months to 136 synodic months we reach the "Metonic Cycle": 19 tropical years is equal to 235 synodic lunar months, or 254 tropical lunar months. A tropical lunar month is defined by the amount of time it takes the Moon to reach the same background stars again - it is equal to 27.322 days. The Metonic Cycle gets its name from a Greek called Meton who lived in Athens in the 5th century BC, and who claimed he discovered this cycle of the Moon himself based on simple observations. Based on our studies of the Lunar Stone at Knowth, we now know the "Metonic Cycle" was known about long before Meton ever existed.

Furthermore, it is highly possible that this kerbstone was used to calculate the exact number of days in the tropical solar year. There are 29 moons in total, 22 crescents and seven circular moons which are really double circles, and potentially signifying an extra count. There is a folk tale still in existence from Brittany to Scotland which says that you should never count stones more than once because you will never get the same number. The numbers and arrangements at Stone Age sites were chosen so that there were several ways of counting them.

If we count the moons, to get 29, and add the second set of circular moons, we get 36. If we double 36 (and the stone already suggests doubling with the waved line - 2x31=62) we get 72, and add the solar spiral, we get 73. 5 times 73 is equal to 365, the exact number of days in the year. Every fourth year, add the solar spiral to get 366. Another 'Lunar Stone' at Knowth can also be used to calculate the exact length of the year, as well as both the sidereal and synodic lunar months.

The "waved line" feature can also be seen to have supplemental counts on the left side, continuing from 31 to 32, 33 and 34. 32 synodic months is also a significant subunit of the Metonic Cycle, because when doubled it becomes 64 synodic periods which ties in with five calendar synodic periods of Saturn. 33 synodic months is one-third of the very important metonic sub-unit: 99 synodic periods ends just two days after eight tropical years. And 34 is one-quarter of another large Metonic sub-unit: 136 synodic months ending about one day before 11 tropical years.

Another Knowth kerbstone can also be used to calculate the lengths of the sidereal and synodic lunar month, and the solar year. I call it the "Lunar Stone". In our look at this 5,300-year-old astronomical puzzle, we will interpret the symbols as follows: the crescent shapes are early and late phases of the moon; the cir-

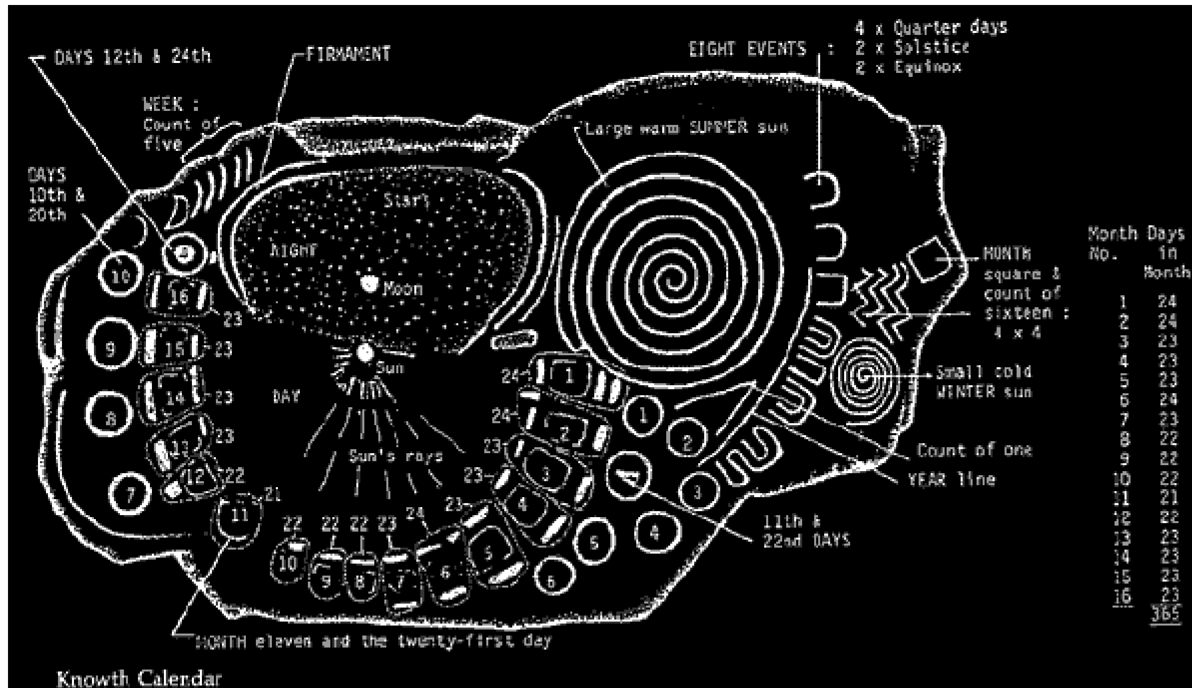
Illustration of crescent moon symbols on the Knowth Lunar Stone

cles are lunar phases close to full moon, the small spiral with a single crescent to the right represents the way the count is carried out, as identified by Martin Brennan; the wavy line represents numbers of lunations, or months, while the line underneath is a calibration bar marking a specific number of [lunations](#) or months.

The 27-day count begins on the extreme right of the stone, working towards the right, a total count of 11 crescents. The eighth phase is marked with a line to indicate a quarter moon. Then the three concentric circles are added to the count, making a running total of 14. Working backwards, we don't count the centre circle because it marks the turning point of the count, and work outwards, adding another two circles, total 16, and then the 11 crescents again, totalling 27. This first method of counting reveals the sidereal month, the length of time it takes the Moon to make one complete circuit through the sky, in other words the time it takes the Moon to return to the same background stars.
The [29-day count](#) works in a similar way, but this time, in addition to counting the outer two concentric circles of the triple circle, the additional double concentric circle on the far top left of the stone is also counted. So we have (working inwards) 11 crescents, plus three circles, total 14, and (working outwards) add two circles, plus another two circles, total 18, plus the 11 crescents again, totalling 29.

This, I believe, is the Synodic Lunar Month count. While the Siderial Month marks the Moon's return to the same background stars, the Synodic Month marks its return to the same phase. Both are important in calculating the 19-year Metonic Cycle. There are 235 synodic months and 254 sidereal months in the Metonic Cycle. Interestingly, another Irish researcher, Gillies MacBain, has pointed out that the original total number of kerbstones around Knowth, 127, is half of 254, or half the number of sidereal lunar months in one Metonic Cycle. Could the whole site have been one large astronomical calculator, with complex movements of the Moon seemingly figured out and recorded for time??

As with the Calendar Stone, the Lunar Stone can be used to work out the length of year. It involves a sim-



The Knowth calendar

ple calculation, using the stone as a guide, and the result is accurate. The length of the Synodic Lunar Month is 29.5 days, and if we do as the stone suggests (in the waved line calibrated count of 12) and multiply the synodic period by 12 (in other words 12 lunations), we get 354.37 days, which is 11 days short of a complete year. One final addition of the 11 crescents will result in the accurate answer of 365 days.

Another very well adorned kerbstone, number 15, seems to contain a combination of a large sundial device and a series of markings designed to help calculate the length of the year. Neil L. Thomas, in his study of the Irish Stone Age symbols of 3,500BC, believes he has identified the manner in which this stone device works.

The Sundial (no. 15): Engraved kerbstone, possibly a lunar calendar symbol, Knowth. Drawing by Martin Brennan superimposed using Photoshop

Thomas says the stone is a unique statement, an exact 365-day, sixteen month, four week month, five day week solar calendar. Brennan identified the large fan-like rayed device on this stone as being a sundial, and stressed the importance of the study of the sun's movements to the people who he called the "master diallers of the New Stone Age". Their dials were constructed, he says, so that they could tell time precisely, even to fractions of a second, but this was for the purpose of making exact observations simultaneously in different places.

There is another sundial at Knowth. It is carved onto the top of a kerbstone on the northeastern side of the mound. On the sundial at equinox, the sun rising in the east casts its shadow west, at midday it casts its shadow north and, as it sets, it casts its shadow east, completing a cross in its circle and defining time and space simultaneously. Brennan says the dial measures what are known as the unequal or 'planetary' hours, which are shorter in winter and longer in summer. At the equinoxes it divides the day into 8 equal parts, which are further subdivided into 16 parts. This corresponds to the solar division of the year into 8 parts.

There is another type of dialling device at Knowth, outside the entrance to the western passage. It is a strangely shaped standing stone, which casts an interesting shadow at an interesting time of the year.

Frank Prendergast said that measuring the shadow cast by a vertical pole, or gnomon, is known to have been used as a simple astronomical instrument from which the approximate time of day or even the altitude of the sun at local noon can be deduced, leading to a reasonably accurate definition of north-south.

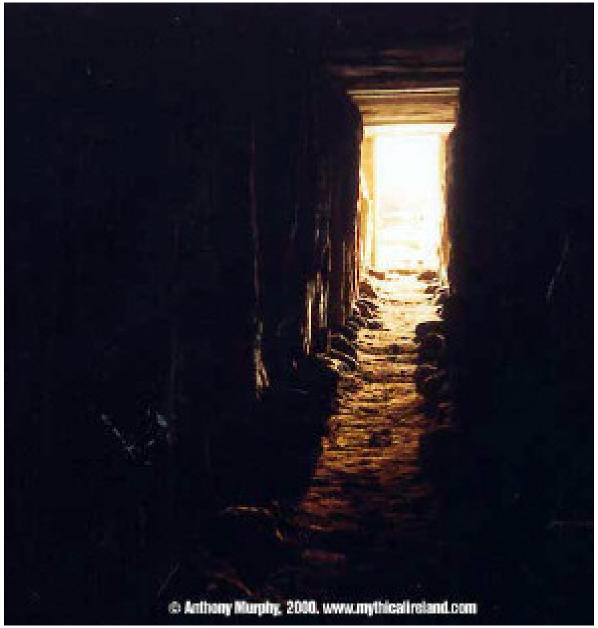
Perhaps the builders of Knowth knew the value of gnomon shadows, because on the evening of maximum penetration of the setting sun into Knowth West, March 3rd, the standing stone casts a shadow on the entrance kerbstone. It does this for a number of evenings at certain times of the year, but it is on the day of maximum penetration that the shadow appears to line

up against the central vertical line of the entrance kerbstone just as the sun sets. I managed to catch the progression of the shadow on film, and the result is interesting. Just as the sunlight is penetrating deep into the western passage, the gnomon shadow lines up perfectly with the vertical centre line on the entrance kerbstone. When it hits the stone, the setting sunlight becomes diffuse and the shadow disappears.

As the shadow event is happening outside, something very familiar is happening inside Knowth West in early March and early October. The long rays of the sun penetrate into the passage and illuminate the darkness, revealing a wealth of decorated stones inside.

Although similar to the Winter Solstice illumination of Newgrange, the Knowth West illumination has not been sufficiently recorded or publicly documented to show exactly how far beyond the bend in the passage that the sunlight actually penetrates.

The Knowth gnomon



The west passage at knowth

Until I took this photograph (above) from inside the western passage around sunset on the Autumn Equinox in 2000, I had never seen a photo of this phenomenon. And even this photo does not do the event justice - this was taken just as the sun was being covered by a large bank of cloud in the west, and moments after I took this picture the sunlight disappeared.

Because the western passage is oriented somewhat south of west, to about 260 degrees azimuth, it is not aligned on the equinoxes as some have claimed, but rather 18 days before the Spring Equinox and 18 days after Autumn Equinox. An American astronomer and researcher, Charles Scribner, has put forward a new theory as to how the alignments functioned. Read more here.

If all of that wasn't enough to whet your astronomical appetite, there's always the work of planetary cartographer, Philip Stooke of the University of Western Ontario, Canada, who claims to have discovered a map of the Moon carved onto one of the stones inside the chamber of the eastern passage at Knowth.

Stooke spends most of his time preparing maps of asteroids based on spacecraft observations, but he has also prepared detailed maps of the Moon, and it was this field of study which made his eyes light up when he first saw a drawing of the carving in an archaeological book about Knowth which he read in Canada. He told BBC Science Correspondent David Whitehouse recently: "I was amazed when I saw it. Place the markings over a picture of the full Moon and you will see that they line up. It is without doubt a map of the Moon, the most ancient one ever found." And all from

Stooke Moon Map

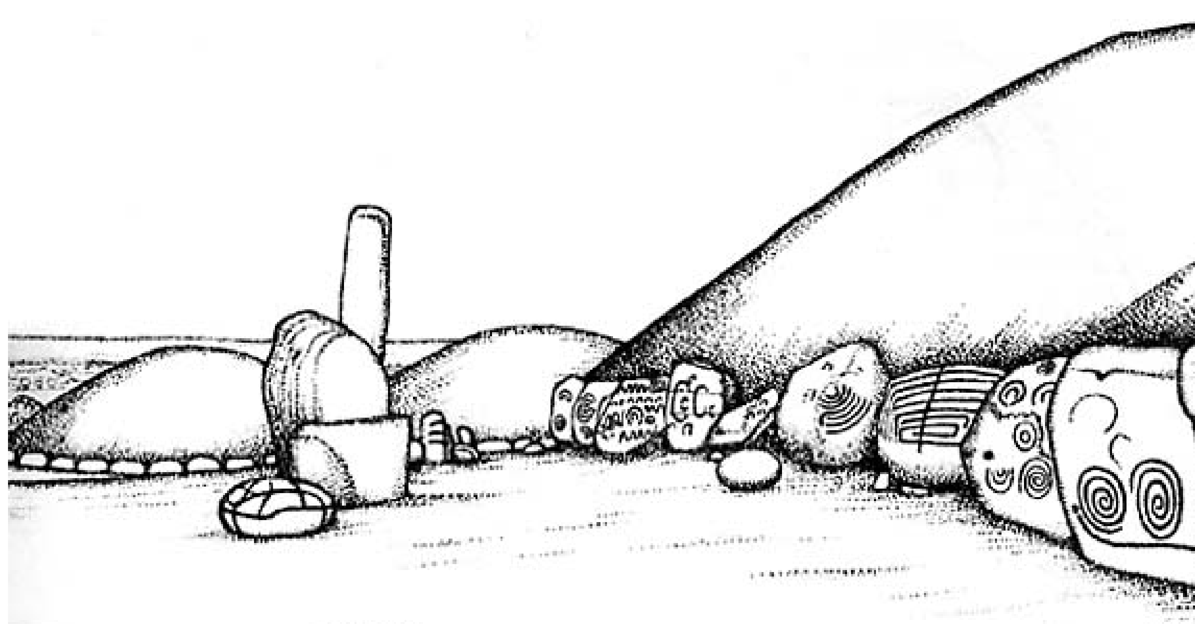
thousands of miles away. In fact, Philip Stooke confirmed to a journalist colleague of mine that he has never been to Knowth. But he plans to visit to see the lunar map for himself.

If his claim is true, it may lend some weight to the argument that neolithic stone passages could have been used to track down Moonrises and Moonsets. In this case, the light of a full Moon rising in the east may once have shone into the eastern passage of Knowth and illuminated the map in the end recess. Who knows?? Later phases of activity at Knowth took their toll - in the early Christian period the construction of souterrains seriously altered the entrance to the eastern passage, and modern archaeological reconstruction has seen the addition of a huge concrete slab at the entrance, so we may never know the full extent of any astronomical alignment the passage might have had.

One thing is certain - Knowth is an astronomical site, and there are a wealth of discoveries which have yet to be made there. There are huge amounts of astronomical symbolism carved into its stones, so much in fact that to say Knowth does not have astronomical functions is tantamount to missing the point. Some of these great stones and carvings are accessible to the public, through organised tours which start at the nearby Brú na Bóinne visitors centre. I would strongly encourage you to go and have a look for yourselves, it really is a wonderful experience.

Further Reading

The Stars and the Stones (Amazon)
Newgrange: Archaeology, Art and Legend (Amazon)
Exploring Newgrange (Amazon)
Early Ireland : An Introduction to Irish Prehistory
In Search of Ancient Ireland (PBS DVD)



One of Brennan's illustrations of Knowth from his seminal book, The Stars and the Stones

The Sikhote-Alin Meteorite

By Mark Bostick

February 12, 1947, a little after 10:30 in the morning: the sun was shining bright through a clear sky in eastern Siberia. An object entered the earth's atmosphere moving north-northeast to south-southwest. Light from this item was so bright that it outshone the sun and was visible for a radius of 300 to 400 kilometers. Secondary shadows of objects flicked across the ground; puzzled eyewitnesses were blinded. To one of these witnesses, a schoolgirl, "*It looked as though the Sun had split off and was falling to earth*." As it continued to cut through the sky, the phenomenon flashed different colors and left a trail of smoke about 35 kilometers long. This smoke remained visible for hours after the fall. It fell at almost a 45-degree angle, with the smoke forming a funnel shape. P.L. Medvedev watched this event from a window at his home in the city of Iman. Medvedey was a painter and quickly painted the image before it left his head. This painting is now famous for a Russia postage stamp that was made on the 10th anniversary. At an altitude of about 4.5 km., it broke apart with a violent detonation that echoed throughout the area. If any locals did not know something was happening, they did now. Following the explosion, rumbling echoed throughout the area. The rumbling was felt by many and seen in the way of unusual visual mechanics. The ground shook, burning charcoals and ash jumped from stoves, doors flew open, and plaster broke from the ceiling. As the object continued to fall, fragments detached and followed the mass to the ground. Some feared the bright light and explosion was from the Americans, dropping an atomic bomb.

Stamp showing the fall of the Sikhote-Alin Meteorite

News was released of the fall, but it this was the beginning of the cold war. So for many years, very little information was shared about the fall. There is no doubt; much was learned about the ballistics of items falling and hitting things. Now more then 50 years later, while much has been written on the subject, very little of it is available in English to the wider world.

296 gram Sikhote-Alin Meteorite Individual

From the eyewitness reports, the orbit of the meteorite was obtained. This orbit extends out to the asteroid field located between Mars and Jupiter. This is one of a handful of meteorites for which the orbit has been calculated and all these types of meteorite have orbits that extend into the asteroid field. This shows a direct relationship between meteorites and the asteroid field. Much has been learned about crater formation as well. None of the meteorites formed explosion craters such as Meteor Crater, but instead a type known as penetration craters.

It was 1975 before expeditions continued again. Their mission was to expand the known strewn field and study the craters' geology. Valentin Tsvetkov joined the team on this trip. Mapping of the craters and meteorites found in the earlier trips showed that the meteorite came from the NNW to the SSE. However, eyewitnesses reported it coming from the NNE to SSW. It was believed a lack of accurate eyewitnesses and the wind blowing the smoke tail made up for the difference. Tsvetkov believed otherwise. Mapping had been done with great effort to search the known area, looking meteor by meteor, being careful not to skip any spot. Tsvetkov chose to search 20-25 meter grids, each separated by 200 meters. To the surprise and possibly annoyance of his superiors, Tsvetkov shortly found meteorites well outside the known strewn field.

These later searches continued for several years. It was shown that the meteorite broke up into several bodies while falling. These bodies continued to break up into groups that fell together and created separate overlapping strewn fields.

The Sikhote-Alin is an iron meteorite. Most iron meteorites are either octahedrites or hexahedrites. Octahedrites have 6-16 % nickel. Hexahedrites have 4-6 % nickel. The sikhote, with 5.87% (+/- 20%) nickel is considered an octahedite, but its composition falls closer to the middle of these two. The meteorite has a granular composition that helped it break apart when it fell. The meteorite has become one of the most popular among collectors and is considered the "queen of meteorites."

Summer solstice! The Sun reaches its most northern house, to begin its journey south once more. Earth cruises past the point in its orbit that results in the greatest tilt of the Northern Hemisphere toward the Sun, and all life responds. Long days, short nights. No one seems to want to sleep, for it is time to celebrate the light!

In Circle, Alaska the solstice party lasts all day, with its culmination at the mid-night hour, people staring at the Sun as it grazes the horizon, straight north. At the North Pole, devoid of anyone to watch, the day has already lasted for three months and will continue for another three until the Sun begins to drop below the horizon, briefly at first, then longer and longer to finally vanish for six months. People at the equator notice the northern and southern solar migration along the horizon, throughout the year, producing wet and dry seasons, but always it is steamy hot and always there are twelve hours light and twelve hours dark. Southern tropic, temperate and Antarctic zones are the antithesis of the northern ones.

People always and everywhere have celebrated the summer solstice. We can only imagine the rituals that took place at Stonehenge on the plain of Salisbury, but contemporary Druids gather there at summer solstice to watch sunrise over the heelstone and claim their relationship with ancient British ancestors, imagining that they can recapture the essence of archaic ceremonies. High in the Big Horn Mountains of northern Wyoming Native Americans once constructed and used a wheel of stones with twenty-eight spokes and a clear summer solstice sunrise alignment. Again, we can not recapture the complete meaning behind this place, but modern Indians and Whites solstice there believing they feel connections to those who made the Bighorn Medicine Wheel. Other New Agers worship at their own personal medicine wheels or at locals in Zion Canyon, Sedona, Arizona and others they have declared to be "places of power." They flock to Chaco Canyon to surround Fajada Butte, crystals in hand, humming chants that they imagine to be ancient, singing the Sun across the sky, believing that power can be transmitted into their lives in mystic fashion.

What really causes the solstice is nothing more nor less than the movement of Earth in an orbit that is tilted to the direction of the equator. This 23.5 degree tilt results in constantly changing solar illumination on the different latitudes of Earth. The explanation is clear and easy to understand, yet the results are truly worth celebrating, for the varying flow of solar energy means everything to our lives. It is enjoyable and of value to understand what we can of the meanings these changes had to earlier people, but the question of genuine values arises when some want to ignore, even dump, understanding in favor of explanations born in ignorance.

Indeed, there are people who behave as if they would discard knowledge and return to earlier times. The number expands amid troubles resulting from growing populations, byproducts of industry and deterioration of religious, family and community strengths. Do not such situations argue in favor of valuing knowledge rather than abolishing it? Isn't it wiser to cherish the understanding we have gained through hard toil running throughout human history, and attempt with all diligence to apply knowledge with great care and sensitivity?

The Big Horn Medicine Wheel

From earliest times until now people have struggled to understand natural realities, such as the causes of the solstices. They found interpretations that satisfied their needs, and they used their

2004 Summer Solstice at Stonehenge

understanding for improvement of their lives. Differing cultures came into contact and shared their interpretations. Such toil and dialogue eventually led to science, an intellectual endeavor committed to free sharing of knowledge for all who might be interested. Such knowledge is power, which, when coupled with wisdom, can expand horizons beyond what is possible in any other way. Yesterday we explored the oceans and continents. Today we travel to the Moon and planets. Remote stars beckon as we await future sunrises.

The people at Stonehenge, those who built and used the Big Horn Medicine Wheel, and the Anasazi at Chaco Canyon, all experienced religious, political and ecological problems. So do we, in context with desires to find and explore new frontiers. The problems and solutions are never easy. Responsible and compassionate uses of knowledge, coupled with retention of solid ethical values, is vital to growth toward our human potentials.

What does all this have to do with the coming of the solstice each year? Annual repetitions are milestones of desired changes. Each time we arrive at this point to enjoy the increased illumination from the Sun, human history on planet Earth has yielded one more year of experience and discovery. We can still look out from the center of Stonehenge to see the Sun rise over the heelstone as it did thousands of years ago, but looking around in all other directions yields knowledge that revises and refines what we treasured before. The traditions of earlier solstices belonged to the people of those generations, and solstice by solstice they transformed to become the ethos we claim as ours, here and now. We should honor and respect the mores of past solstices, while we apply products of knowledge for the benefit of all mankind and the other creatures we share Mother Earth with.

For more equinox insights (and some pictures of balancing eggs) visit Phil Plait's Bad Astronomy site. Another good article is Phil's What Causes the Seasons?

Also available at the U.S. Naval Observatory's site is an article on the Comparative Lengths of Longest Day and Longest Night, and of Shortest Day and Shortest Night and UCAR has a nice explaination of the solstice.

And finally the Science Alliance has conducted egg balancing experiments with teachers.

The 2005 summer solstice will occur at 12:46 a.m. MDT (06:46 GMT), 21 June 2005, when summer begins in the Northern Hemisphere.

Druid Festival

In June 2003, Druids from across England descended upon the Custard Factory in Birmingham for a summer solstice celebration billed as a perfect day out for the whole family. The Church of England condemned the festival, however, when Candia and her pagan rock band Inkubus Sukkubus, announced plans for a fertility rite.

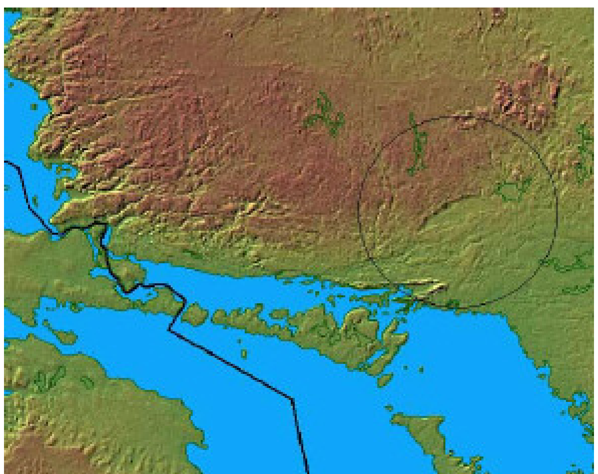
"They said they needed a quiet fornicatorium," a Custard Factory spokesman explained. "The singer goes into a trance-like state. We don't quite know what will happen once the frenzied activity begins." The Church's response? "It seems the Druids have overdosed on the magic mushrooms when arranging this event," a spokesman said. "It beggars belief that this kind of tackiness and tawdriness is being promoted as a cultural family event."

Aerial Explorations of Terrestrial Meteorite Craters

By Charles O'Dale

The Sudbury Crater

While documenting the Sudbury Meteorite Crater (Ontario, Canada) from my airplane and from the ground, I realized that for a non-professional geologist the geographic features that state that "this area is a meteorite crater" are not obvious. For this reason, the initial content of my article will be a geologic description of the remnants of the present day Sudbury Meteorite Crater (highlighted by the circle in this topographic image). I will also document the evidence stating that the anatomy of the Sudbury complex was formed as the result of a bolide impact. In this way I hope to better explain my aerial and ground images of the crater.



I want to thank Frank Brunton and James E. Mungall for their assistance and allowing me to quote from their published papers (listed at the end of this article).

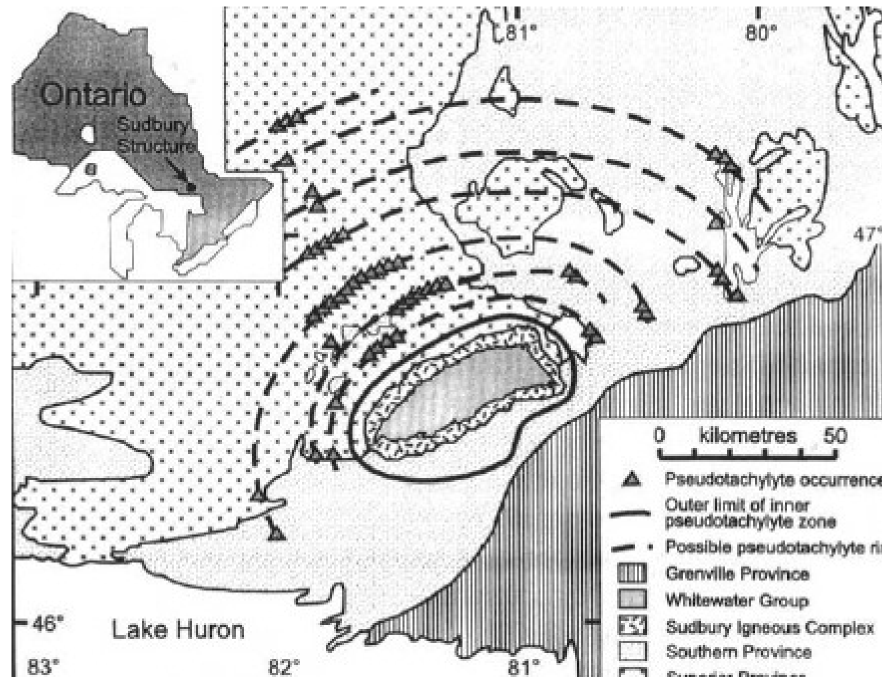
The Sudbury Structure comprises a 200-250 km multi ring impact basin formed 1.85 billion years ago. The core of the structure is elliptical, 60 x 30 km, containing a layered 2.5 km thick impact melt sheet, referred to as the Sudbury Igneous Complex (SIC). The SIC was formed by differentiation of the impact melt pool at the probable main point of the bolide impact.

Formation of the Crater

The Sudbury Structure is situated within a unique Geotectonic setting in northeastern Ontario, being sandwiched between:

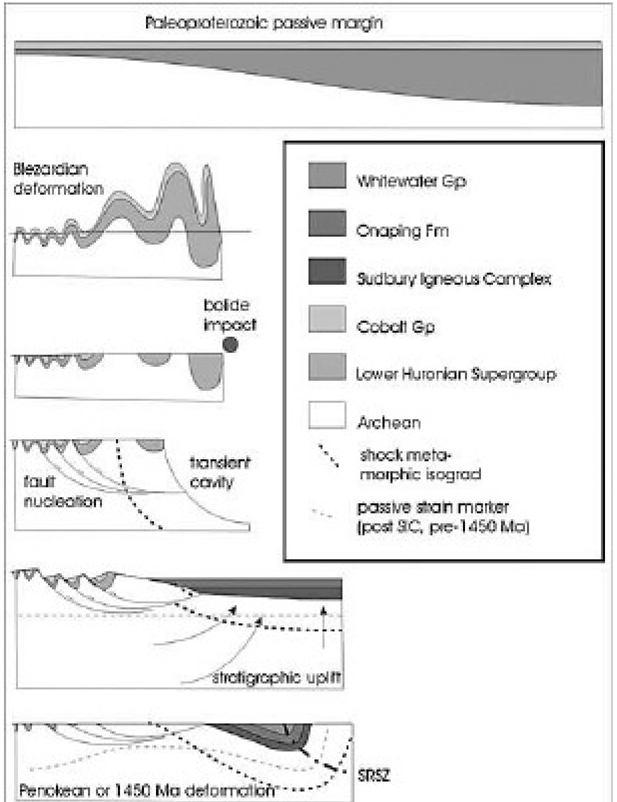
- the Archean-age (>2.5 billion-year-old) Superior Geologic or Structural Province, situated to west and north of the structure, and;
- the Proterozoic-age (>1.9 billion-year-old) Southern Geologic or Structural Province Huronian Supergroup, deformed by the (1.9 billion –year-old) Penokean orogeny , and situated to west, south and east of the Sudbury Structure.

The boundary of the Proterozoic-age (~1 billion-year-old) Grenville Geologic Province presently lies approximately 10 km to southeast of the SIC. The Grenville



orogeny occurred 800 million years after the Sudbury Meteorite Crater bolide impact. The SW-NE trend of the Grenville Front Structural Zone, which delineates the northernmost margin of the Grenville Structural Province, is roughly parallel to the long-axis of the SIC. (Note 2).

Illustrated in the sketch below (courtesy of James E. Mungall) is a view of the sequence of events that may



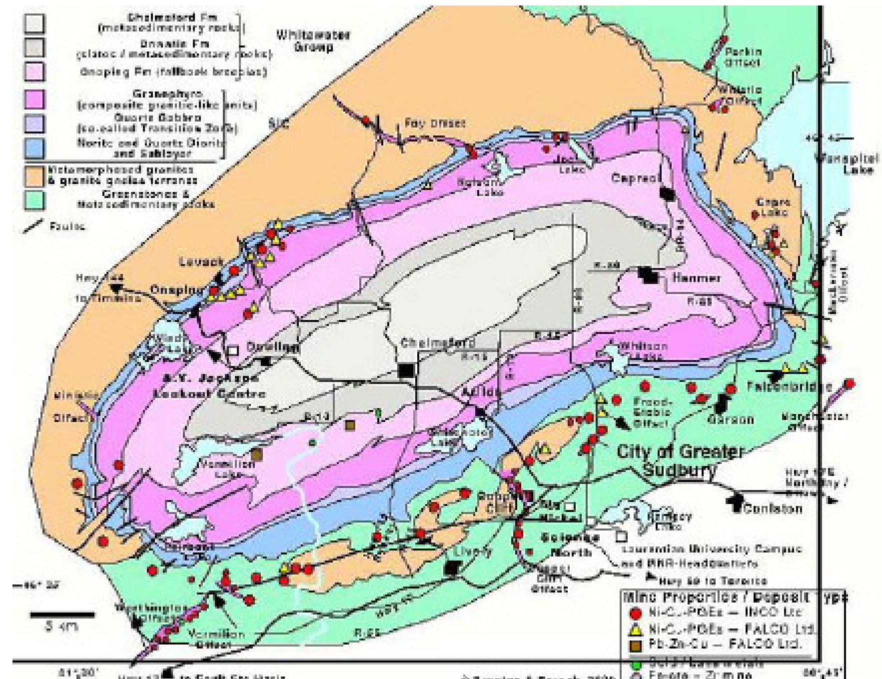
have produced the current structural relations between the SIC and the Huronian outliers (Huronian sediments were deposited between 2,450 and 2,219 Million year ago on the subsiding margin of the Superior craton). The transgressive nature of the passive margin produced a sequence which onlapped and thinned progressively toward the northwest. The Blezardian orogeny caused the formation of basement-cored tight folds in the metasediments, which were peneplained and submerged 1,850 million years ago.

1,850 million years ago, the impact of a large bolide created a transient crater at least 100 km in diameter and 30 km deep somewhere in the vicinity of the current SIC. Within about ten minutes of the impact, the crater had rebounded and collapsed into its final form. Inward collapse of the transient crater walls was accomplished along detachment surfaces, now preserved as anastomosing networks of pseudotachylite-filled faults (Sudbury Breccia) tens of km in length. Lateral collapse and structural uplift in the center worked together to form a crater approximately 200 km in diameter.

The South Range Shear Zone (SRSZ) line on the sketch is the transition from pristine North Range to deformed South Range of the SIC and occurs over a distance of less than 20 km. (Note 1).

Segments of the Crater

The Sudbury Structure is interpreted to represent the tectonized and deeply eroded remnant of a multi-ring or peak-ring impact basin (Stoffler et al). Approximately 4 km of erosion over the eons has obliterated the crater rim. Tectonism has possibly deformed the original crater into an ellipse. The subsequent metamorphism in the structure is tied to tectonic activity such as collision of continents and folding and thrusting up of crustal rocks. A zone of deformation (shatter cones and rock metamorphism) has been documented to 74 km from the SIC.



This geologic schematic (previous page) of the Sudbury structure (courtesy of F. Brunton) illustrates the present day remnant of the Sudbury Meteorite Crater comprising of:

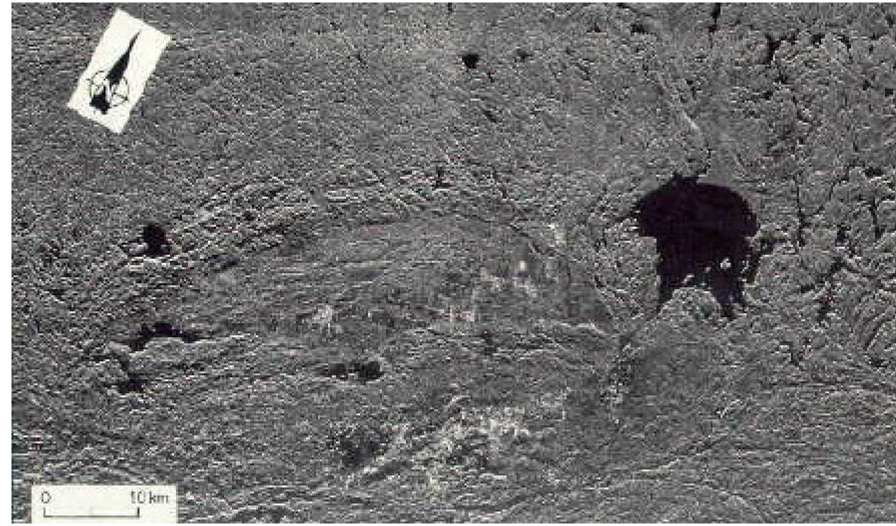
- the surrounding brecciated footwall rocks of both the Superior and southern Structural Geologic Provinces extending up to 100 km away from the present-day position of the Sudbury Igneous Complex (SIC);
- the Sudbury Igneous Complex (that formed as a result of impact-triggered magmatism, or deep crustal melting); and
- the Sudbury Basin within the SIC, comprising rocks of the Whitewater Group (found only in the interior of the SIC). The Whitewater Group consists of the Onaping, Onwatin and Chelmsford Formations (Note 2).

Landsat image of the Sudbury Crater area

The Sudbury Igneous Complex (SIC)

Thick sheets of melted rocks line the bottom of many large meteor craters. Some of these impact melts are derived from the release of kinetic energy at bolide impact that is converted to heat. Also, rocks lying kilometers deep within Earth are often on the verge of melting but are prevented from doing so by the immense pressure from the weight of the material lying above them. A large bolide would blast away this weight, releasing the pressure on the buried rocks and causing the underlying minerals to melt.

The impact melts may not fully cool for hundreds of thousands of years. In the meantime, water from the environment and the heat from the newly exposed rocks can combine to form hydrothermal systems in the heavily fractured rocks in and around the crater. Scientists believe such warm mineral-rich venues could have played a role in the early development of life on Earth. (Science News: 3/9/02, p. 147) Evidence of the hydrothermal systems is documented in my ground tour.



Aerial radar iamge of the Sudbury Crater

The SIC is this type of large melt sheet produced from crustal melting resulting from a bolide impact. The target rocks, which remained within the crater after the impact, ponded to form a sub horizontal sheet of magma and differentiated as it cooled. It is currently exposed as an elliptical 60 x 30 km, 2.5 km thick remnant of the original impact melt sheet and consists, from bottom to top, of inclusion-rich, in places ore-bearing, quartz diorite sub layer, norite, quartz gabbro, and granophyre layers, and, within the target rocks surrounding the SIC, the quartz dioritic offset dikes.

When the crater is viewed from the altitude of the International Space Station, only the SIC within the Sudbury Structure (highlighted by the oval in the landsat image) is identifiable as being related to an impact event. The structure is located in central Ontario, north of Georgian Bay and north-west of Lake Nipissing (Note

3). The city of Sudbury is located to the south-east of the SIC.

In the aerial radar image of the Sudbury Structure, the Lake Wanapitei Meteorite Crater is visible adjacent to the distorted east edge of the SIC oval. Quantitative evidence stating that the deformation of the SIC in this area was caused by the Wanapitei impact has not been documented to date (2004). The close proximity of these two impact structures is strictly coincidence. The Wanapitei crater occurred over 1.8 billion years after the Sudbury impact. (Image courtesy of Earth Impact Database, 2003: www.unb.ca). (Note 4)

Picture 1 - Sudbury Crater from the air

The Whitewater Group

The SIC is overlain by the 1.8 km thick Onaping Formation. It consists of impact melt breccia, suevite and reworked suevite from:

- Fall-back (collapse of the original crater) and Fall-out (impact debris) forming a 2 km post impact sediment over the SIC melt rock; and,
- Wash-in – post impact sediment (the impact happened in a shallow sea).

The rock fragments in the breccias of the Onaping Formation are from the impact target Archean and Proterozoic rocks of the Superior and Huronian Provinces of the Canadian Shield. (Note 2)

The Onaping Formation is covered by 600 metres of argillites and minor exhalative carbonates and cherts of the Onwatin formation. This formation occurred during a period of quiescence after the impact basin formation.

The end of this quiet period was signaled by the abrupt appearance of the 850 metre-thick siliciclastic turbidites (sedimentary deposits settled out of muddy water carrying particles of widely varying grade size caused by turbidity currents) of the Chelmsford Formation (Rousell, 1972, 1984), which have been interpreted as a flysch apron deposited in the foredeep ahead of an advancing late Penokean mountain front (Young et al. 2001).

Aerial Tour

At series of images will document my aerial exploration the crater, first from the north outside of the SIC, and gradually working across the structure to the south. Most of my images were from approximately 2,000 feet above the ground.

Picture 1 was taken from the north of the structure while flying over the Superior province country rock. In the immediate foreground is the area containing the Matachewan dykes and the Sudbury Breccia followed by the north rim of the SIC comprising of the different minerals of the lower and upper zones. Here at the time of impact, a 1 km cross section of country rock surrounding the crater was instantaneously melted, forming about 31,000 cubic kilometers of impact melt! This represents approximately six times the volume of lakes Huron and Ontario combined, and nearly 70 percent more than the melt at Chicxulub (Pope, Geo Eco Arc Research). In the background is the internal bowl shaped portion of the SIC containing the Whitewater group.

Picture 2 (next page) was taken above the SIC north rim. The internal edge of the SIC is illustrated here by the Vermillion River which is immediately adjacent to the internal north rim of the SIC and meanders through the relatively flat area of the Whitewater Group. All geology enclosed by the SIC is a result of fall-back, fall-out and wash-back.

Picture 3 of the floor of the Sudbury Structure was taken from about 3,000 feet over the center of the structure looking east over the Proterozoic rocks of the Whitewater group. The deepest mine shaft in the Sudbury complex, the Creighton Deep Project, is more than twice as deep as the altitude where this image was taken from! The northern rim of the SIC is visible in the left of the image with Lake Wanapitei in the left background. The town of Val Therese is in the fore-

Picture 2 - above the SIC north rim

Picture 3 - the floor of the Sudbury Structure

ground with the town of Hanmer just behind and to the east. I took the ground image (below) of the SIC north rim from just west of Hanmer. Garson Lake visible to the extreme right of the image is situated in the center of the southern rim of the SIC. The long axis of Garson Lake points at the Sudbury airport which is at the south east SIC origin of the South Range Shear Zone (SRSZ). It is barely visible in the haze in the background. The meandering river visible to the north (left) of Garson Lake is approximately over and running parallel to the SRSZ.

Picture 4 (next page) shows a lower altitude image looking north east from directly over the north-east corner of the Whitewater Group. The relatively flat geology of the Whitewater Group is terminated by the sharp north east rim of the SIC. In the background beyond the SIC is Lake Wanapitei. Under the Sudbury Basin are thousands of kilometres of drifts (lateral tunnels) and shafts (vertical to inclined tunnels) cut into the SIC to extract nickel. If these tunnels were placed end-to-end across Canada, it would almost be possible for someone to drive, bike or walk from coast to coast underground!

Picture 5 (next page) shows the south rim of the SIC illustrated is not as well defined as the relatively intact northern rim. The infamous Sudbury "stack", visible in the foreground, rests on the Huronian supergroup south of the SIC. The SIC south rim is visible as the "mound" behind the stack and the "bowl" of the internal Sudbury Structure is visible in the background. To give an excellent perspective of the size of the structure, the north rim of the SIC is barely discernable just below the horizon in the far background!

This area has the single largest magmatic nickel source in the world. The Creighton Deep Project is currently mining and actively exploring well below the 7,500-ft. level, maintaining its status as the deepest working mine in the western hemisphere. The size of the underground workings at Creighton dwarfs all man-made structures on the surface of the Earth. The No. 9 vertical shaft is between 4-5 times higher than the CN Tower!

The Sudbury Neutrino Observatory is housed in a cavern as large as a 10-story building, in the deepest section of the Creighton Mine.

The 200-m-thick impact melts found within the Sudbury Crater are a treasure trove of minerals. More than $1 billion of metal ores including those bearing nickel, platinum, and copper are mined from the melts each

Pictuer 4 - lower altitude image looking north east from directly over the north-east corner of the Whitewater Group

Picture 5 - south rim of the SIC illustrated in this image is not as well defined as the relatively intact northern rim

year. Isotopic analyses show that the metals come from Earth's crust, not from the meteorite that fell from space. Before the impact melt solidified, the deep, thick blend of light silicates and dense metal ores - which didn't mix well with each other - separated into two layers, according to density, just like oil and vinegar do. This ancient segregation makes mining today much easier. (Note 2)

The hydrothermal system created by the Sudbury impact also dissolved minerals containing copper and other metals from a broad area and then concentrated them in rich veins. (Richard Grieve, Natural Resources Canada in Ottawa).

(to be continued)

Apollo 11: Stranded on the Moon?

On July 20, 1969, Neil Armstrong, Buzz Aldrin, and Michael Collins became the first human beings to land on the moon. Incredibly, the trio was almost stranded there after Armstrong accidentally knocked the lunar module's ignition switch flush against the wall while swinging his back pack as he re-entered the craft. To their horror, the men realized that thay had no tools with which to pry it loose; all unnecessary weight had been jettisoned in preparation for lift-off.

Finally, Armstrong realized that he had just the tool for the job at hand: the much-maligned "space pen." Ironically, Senator William Proxmire of Wisconsin had famously fulminated about funds being "wasted" on the pen's development. "Why not use a pencil?" he asked. Had NASA listened to Proxmire, Armstrong, Aldrin, and Collins would still be on the moon...

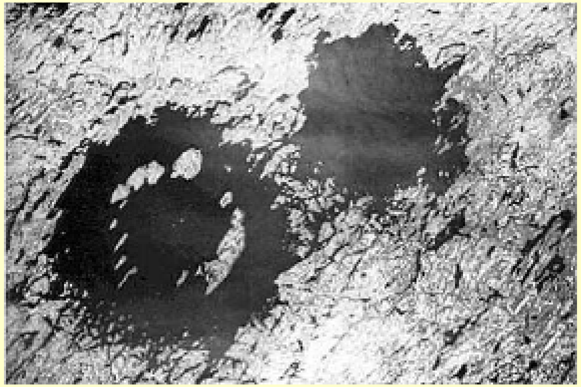
Notes

1. J.E. Mungall and J.J. Hanley: ORIGINS OF OUTLIERS OF THE HURONIAN SUPERGROUP WITHIN THE SUDBURY STRUCTURE. Department of Geology, University of Toronto.

2. Frank Brunton: THE FACTS-SIGNIFICANCE OF SUDBURY GEOLOGY & MINING HISTORY. This is Frank Brunton beside my chariot, C-GOZM immediately after our aerial exploration of the crater. Note the F18 in the right background. The Sudbury airport is on the east rim of the SIC and directly over the South Range Shear Zone.

3. In the Landsat image (see start of article) observe Lake Nipissing to the east of the Sudbury Structure. There are two circular features on Lake Nipissing whose geological features are unexplained. They are documented in the two images (below right) taken from the north coast of the Lake Nipissing looking south. At the extreme east of Lake Nipissing, by the town of Callander, is a circular feature that resembles a caldera. In the eastern area of Lake Nipissing are the Manitou Islands, a series of small islands placed in the form of a circle. A third feature, a semicircular indentation into the north coast of Lake Nipissing at Meadowside, was probably caused by wave action erosion of the soft coast material.

4. The close proximity of the Sudbury and Wanapitei impact structures is strictly coincidence. The Sudbury impact happened over 1.8 billion years before the one at Wanapitei. In another coincidence, relatively nearby in northern Quebec's Canadian Shield, is another double impact site, the Clearwater East and West impact structures. The Clearwater impacts, shown in this image, are related and simultaneously occurred 290 million years ago. Image courtesy of Earth Impact Database, 2003: (www.unb.ca).



The Clearwater East and West impact sites

Callander

Manitou Islands

RTGUI Freeware for Telescope Control

By Rod Mollise

Is simpler better when it comes to astronomy software? Previously, I hadn't thought so, being unable to resist loading my hard drive up with more and more multi-gigabyte wonders like The Sky 6 and Starry Night Pro. There's no denying, certainly, that these programs can do a lot. Make that "almost anything," from showing you what the sky looked liked in the days of the ancient Egyptians, to helping you hunt down the last of those Herschel 400 fuzzies. Of course, to do that you'll find yourself feeding your PC CD after CD (or, now, DVD after DVD), and unless you've got the latest blazing-hot machine from Alienware, you're likely to soon have a maxed-out hard drive packed with programs that run as slow as molasses.

Even worse, if you're like most amateurs, you use a less than state-of-the-art PC as your observatory or field computer. A 300mhz laptop or desktop being more dew-worthy than the latest gigahertz greyhound. I can hear it now, "But Uncle Rod, I *have* to have The Sky 6 (or Desktop Universe, or whatever). How else can I make my goto goto?

Good question. But I've got a question for *you*. How many of the features of those mega-sized programs do you really use? Be honest, now. I'll bet all you use most of the time is the program's search function to find objects and its goto capability to send it there. Look, Skeezix, you do NOT need a 300 dollar program on 5 CDs to do that. That's what I found out when I was introduced to the freeware program, RTGUI.

What's an RTGUI? RTGUI stands for "Real Time Graphic User Interface." It's a small program, at a download size of 500K and an installed size of about twice that, and runs incredibly fast and well on older machines. What can it do?

- Show's the observer what's visible instantly, using its GUI interface. No need to prepare observations in advance. Find deep-sky objects or stars by their common names. Unusually rich search capabilities - each entry has up to five different names (Example: *M1, NGC 1952, CrabNebula, Taurus, Planetary*)
- Create a custom "tour" based on your own criteria (by constellation and/or object type, elevation, magnitude).
- Small and fast - Download is about 500k.
- Controls most Celestron and Meade "Goto" telescopes to slew directly to the selected object!
- Using the Skycharts program (Cartes du Ciel), get an "instant sky chart" of the selected object.
- Read hand-held GPS Devices or Celestron and Meade GPS Telescopes to set highly-accurate Location and System Time. Read object position from most Celestron and Meade Goto scopes. Upload data from GPS devices to Meade Goto scopes.
- Locate Sun, Moon, and Planets, with excellent accuracy. Transient Catalogs exist for automatically finding bright comets, etc.
- Can set the "night vision" color palette in Windows.
- Displays Altitude and Azimuth of Astronomical Objects, updated in Real-Time, along with Rise and Set times.
- Automatically record object, time, & location information when the Observing Log is opened
- Auxiliary Catalogs allow you to instantly locate hundreds of thousands of objects, using standard astronomical nomenclature, a time-saving tool for observing projects and for research.
- · Command-Line Parameters allow Scripting for automated operation

That's a lot, huh? Sure is. Maybe everything you normally want to do with an astro-ware program? The first thing you need to do if you're interested in RTGUI, of course, is download the sucker and get it installed. There's not much to that, you download it from the url above and unzip it into a directory you create (normally "RTGUI"). You then manually create a Windows shortcut icon for the executable program file for your desktop. It would be nice if RTGUI had an installation program that took care of these things for you, but let's not quibble. This is freeware, after all, and RTGUI does indeed do all those things in the list above, and does them speedily, simply and reliably. If, like me, you're not overly computer savvy, you can undoubtedly find a buddy to help you get the program set up on your hard drive.

The big draw for most of us will be RTGUI's ability to command a goto scope, that's the raison d'etre for the program, really. RTGUI is capable of interfacing with the following telescopes:

- Meade LX200GPS/LX200
- Meade LX90
- Vixen Skysensor 2000
- Mel Bartels System
- Celestron Nexstar GPS
- Celestron CGE
- Celestron Advanced Series
- And numerous others (see the website for a complete list).

In order to get this interface working, you have to inform the program of two things: the type of goto scope you have (Meade or Celestron, and, the particular model) and the com port that your PC uses to talk to the telescope. That's it. I was truly impressed that it was so simple to set the program up for my scope. Most freeware/shareware programs require you to download, install and configure the ASCOM program for goto functions to be enabled. ASCOM is nice, but it can be a bit daunting for novices and computerphobes to get going. And it does eat away at the disk space, it alone taking up more space than the whole RTGUI program.

Once you've got RTGUI installed and configured for your scope, you'll soon find how wonderful life can be in "slow lane" of the computer/software information highway. Want to go to an object? Nothing could be easier: click the "simple search" button, type in the object's designation - M31, NGC 2024, or whatever (the program's default catalog is the NGC/IC - and, when the object's vitals are displayed in RTGUI's little window, hit the "goto" button. That's all there is to it. This works perfectly with my Nexstar 11 GPS, a newer

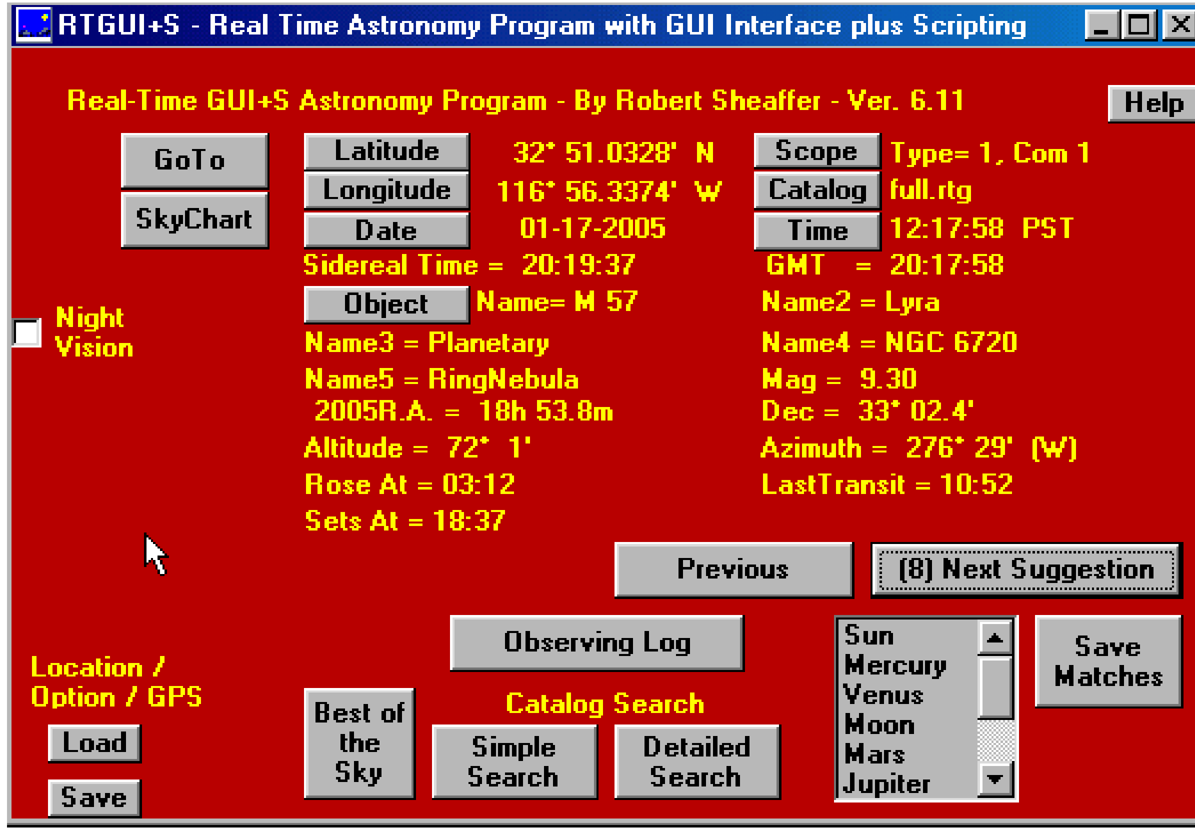


Figure 1: The "Real Time Graphic User Interface" screen

scope with a newer way of doing things than the time honored LX200 protocol, so it should work just as well with your blue tube 'scope.

Frankly, the above is mostly what I do with this program. Or any astronomy program hooked to my telescope. It's all I *need* to do. But that's not all RTGUI *can* do. Despite its size and quickness, it has a lot of features, and the author is adding more all the time without compromising the program's basic simplicity. One of the most important of these "extra features" is the program's advanced search capability. Sure, Old Rod usually just stays with the "simple search" button, but you can also do things like display all the globular star clusters in Sagittarius. The richness of these search abilities almost allows RTGUI to qualify as a "planner."

Another feature that may allow this little wonder to be used in place of your humongous observing planner program is its "tour" creation ability. Make up a list of objects using the program's search engine, and you can have RTGUI send your scope to each of your chosen "stops." Not only can you send the scope to each entry in a list of objects, you can record your observations and impressions of those objects using the RTGUI's built-in logging capability. The program will automatically appends the current date and time to these entries, ensuring that your observations stay organized (at least more organized than the index card file Rod used as a log for many years). Truthfully, RTGUI may be all the planner a lot of folks need.

Naturally, for the program and a goto scope to be able to work together correctly, times, dates and locations must be set and set exactly in the scope and in the computer. That's no problem for the scope if it has a built-in GPS receiver. But how about the computer you are using to run RTGUI? One of the nicest features of the program is that it can read position and time from the scope and set these parameters in your commanded to ask the telescope where it is currently pointed and display its position for you.

One other GPS-related feature that is of special interest for non GPS Meade goto scopes is RTGUI's ability to *read* handheld GPS receivers. You can download the receiver's time and position data to RTGUI and then *upload* this information to your LX90 or other non GPS scope. That means that your little 90 suddenly has a lot of the features of its more expensive big brother, the LX200 GPS.

One thing I'm often asked when I start enthusing about this program is, "How can RTGUI, which is tiny as astronomy programs go, create decent starcharts?" Easy: it doesn't. Or, actually, it does, but not on its own. Having a star chart display is not completely necessary if you're using a goto scope, but it is still nice to be able to display a map to graphically show where the scope is pointing and to jog your memory as regards other objects of interest in the area. RTGUI provides charts by furnishing an interface to another freeware program, Cartes du Ciel. CdC is a fantastic planetarium that will do anything the expensive software will, and provides RTGUI with charting/atlas capabilities every bit as useful as those in the big, expensive software. Search for and display an object in RTGUI, hit the "Skychart" button, and CdC is opened and appears onscreen with the object of your choice centered.

One thing most computer-crazy amateurs always want to know about a program is "how many objects?" RTGUI is no slouch in that department, coming equipped with the NGC/IC, which is more than enough for most of us, but it can be expanded easily, with numerous add-on catalogs already available for download from the program's website.

Another welcome feature is of altitude and azimuth values for selected objects, and its ability to display rise and set times. This is another of the program's capabilities that lessens the need for you to go elsewhere for the data you need to plan and execute an observing run. Rounding out RTGUI's feature-stable is the ability to set the program's colors to night-vision friendly ones. For most laptop displays, the night-vision setup is just right. Also, while the program's window can be maximized, its simple layout only requires the small window shown in Figure 1, so most of us will run it as shown rather than expand it to fill the entire screen. Because of that, the program's ability to set Windows' colors to a night-vision color-palette is very welcome.

Oh, one last thing. The latest feature of RTGUI is its new ability to run "scripts." That means the user can write a list of commands for telescope positioning which RTGUI will execute, pointing the scope at specified objects without human intervention. That sounds like the kind of computer wizardry that's far outside my needs, but it's nice to know that the program will do things like that for people smart enough to need such high-falutin' technology. In summary? If you've got a goto scope, you need RTGUI. Like its freeware sister, Cartes du Ciel, it works incredibly well, and has no downside. RTGUI is *so* good that I cannot believe Robert Scheaffer is giving it away for *fre*e. But, shhhh!, let's not tell *him* that.

The software can be downloaded from:
http://www.debunker.com/astro/rtguipage.html

Hawking's Voice

In April 2001, Stephen Hawking, long-suffering from motor neurone disease, visited Vickram Crishna, a specialist in audio communication and software development in Bombay, to discuss a new project for several hours.

The project? To replace his electronic voice's American accent (transmitted from a computerised machine attached to his wheelchair) with an English one.

["I have some nice English accents on my Macintosh," Crishna explained. "He can take a range of options and fine-tune them, maybe to take something close to the way he spoke as a young man and update it for a man in his fifites." Hawking lost his voice after a tracheotomy in 1985.

Canon EOS "Digital Rebel"

by Phil Harrington

It seems like it was just last week, but it must have been 6 or 8 years ago now that my friend Brian and I were debating the future virtues of digital imaging versus traditional film-based photography. I remember saying that, sure, digital cameras are fun, but for real photography, you can't beat film. Words to live by then; words to eat now. It's absolutely amazing the strides that have been made in the world of digital imaging. Just leaf through the inserts in any Sunday newspaper and you are bound to see advertisements for digital cameras selling for under $100. Given how fast that industry has grown, the film industry is doomed.

Digital imaging isn't news to amateur astrophotographers, who have been using CCD (charge-coupled device) imagers for years. But face it, those can be a hassle. You have to carry out the telescope, the imager, as well as a computer and cables, and then usually hook everything up to a power supply of some sort. Sure, the results are amazing, but the time and effort it takes, to say nothing of the expense, means that relatively few of us take full advantage of the technology.

At the other end of the cost spectrum, astro-imagers are producing stunning photos of the Moon and planets using inexpensive webcams, such as the Philips ToUCam or the new, low-cost imagers from Meade and Celestron. Of course, all of these are also designed for through-the-telescope imaging only. And there's still the hassle of having to bring out a laptop, setting everything up, and then wrestling with cables in the dark.

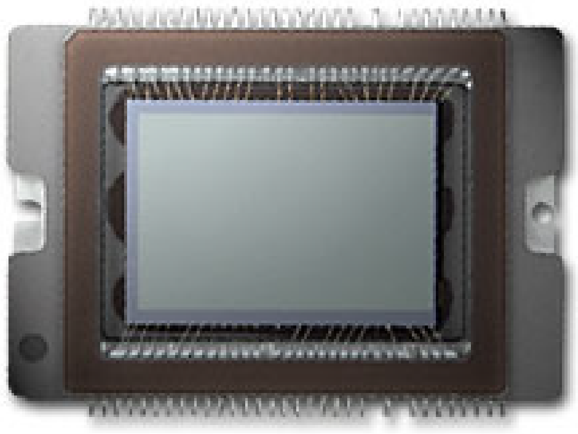
A new and evolving segment of the consumer digital market premiered a few years ago, but has only recently come down from the uppermost levels of the pricing stratosphere. Digital single-lens reflex (DSLR) cameras combine the best features of traditional 35-mm single-lens reflex cameras, including manual exposures and, in most cases, removable lenses, with the all-in-one convenience of point-and-shoot digital cameras. They are as adept at astrophotography as they are at capturing family portraits.

The Canon EOS 300D Digital Rebel

Of all the DSLRs sold today, the Canon EOS Digital Rebel is the least expensive (though at a retail cost of $1,000, it still isn't exactly "cheap"). I purchased a Digital Rebel in March 2004, and have since used it under a variety of terrestrial and astronomical circumstances. Overall, I am very happy with it, although there are a couple of design issues that plague astrophotography. More about that later, but first some statistics.

The 6.3-megapixel Digital Rebel (also known as the Digital Kiss and EOS-300D, depending on where you live) is available as the body alone for $899US, or in a package that includes an 18-55mm f/3.5-5.6 zoom lens for $999US. I purchased the latter, but either way, you also get a BP-511 Li-ion rechargeable battery pack and charger, neck strap, USB and video cables, CD-ROMs featuring EOS Digital Solutions 6.0 and Adobe Photoshop Elements 2.0, and camera and software manuals. But no memory card. Like most manufacturers, Canon leaves that up to you. The Digital Rebel takes a CompactFlash card, which is readily available in almost any electronics, camera, or department store. Expect the card to add another $50-$150US to the investment, depending on its capacity.

Outwardly, the EOS Digital Rebel looks just like a regular camera. The plastic body, complete with its faux titanium color, looks identical to Canon's EOS Rebel K2 35mm SLR as well as others in Canon's 35mm SLR line-up. The family resemblance also means that the Digital Rebel can use any EOS-compatible lens that is sold either by Canon or by aftermarket companies. Just remove the 18-55mm lens that comes standard and replace it with another.



Canon's CMOS Sensor - the DIGIC Chip

There is a catch to this, however. Even though you can use a standard EOS-compatible lens on the Digital Rebel, the effective focal length is multiplied by a factor of 1.6. In other words, a 100-mm lens is effectively stretched to 160mm when used with the Digital Rebel (the f/ ratio remains unchanged). The problem is that, since the Digital Rebel's CMOS (Complementary Metal Oxide Semiconductor, above) image sensor is smaller than a 35mm film negative, each photo only captures the central portion of the lens' field. That's fine for telephoto and zoom lenses, but will decrease the field of view for wide-angle lenses. Before you bemoan this situation, realize that the edge of a lens' field is always the most prone to image degradation from optical aberrations. By capturing only the central portion of the view, the Digital Rebel can actually improve results from a given lens.

Layout

Scattered all around the body of the Digital Rebel is an array of buttons that let you set the camera's many modes and adjustments. On top of the camera, in the traditional location of the shutter speed wheel, is the mode selector knob. Rotate the knob to choose between auto exposure, program mode, aperture priority, shutter priority, manual exposure, as well as six "scene modes" (portrait, fast action, etc.). Immediately next door is the on-off switch.

Adjacent to the mode knob and on-off switch is a button to switch the camera between single exposure, sequence exposures, and self-timer/remote. The latter is of most interest to astrophotographers. Just as film photography is on the wane, so are mechanical cable releases. Instead, most modern cameras use small wired or wireless shutter releases to trigger the shutter remotely. In the case of the Digital Rebel, you can pick up the Canon RC-5 wireless remote control for about $20. To take a long exposure, set the camera to timer/remote and press the RC-5's button. After the camera beeps and self-timer light flashes for 3 seconds, the shutter will open. Pressing the button again will close the shutter. The remote works very well, although the white self-timer light seems very bright at night -- but nothing that a piece of black electrical tape can't cover.

Finally, there is a hot shoe on top of the penta-mirror housing, although given the pop-up flash that's built into the camera, I've never had a need to use it.

Top: Shooting Controls
Bottom: Digital Controls

Other controls are clustered around the 1.8-inch LCD screen on the back of the camera body. Five buttons immediately to the left of the screen include:

- Menu, with controls for image quality, white balance, memory card formatting, and more
- Info, which shows current settings, such as date, time, image histogram, and exposure information
- Jump, which lets the user go forward or back 10 images in playback mode
- Playback
- Delete image

To the right of the screen are controls for lens aperture, ISO setting (adjustable from ISO 100 to 1600), and pan buttons. The pan buttons, as well as a nearby pair of zoom buttons, let you move around an image displayed on the LCD screen. (A sidebar note: The LCD screen is only for reviewing images already taken, not for previewing a shot prior to exposure.)

Exposure values are visible both in the eyepiece as well as on the back of the camera body, just above the LCD screen. Canon thankfully included a backlight on the backside exposure panel, which makes it much easier to see what you're doing at night.

All of the I/O ports, including USB 1.1, video out, and

remote shutter release cable, are found under a rubber cover on the right side of the body, while a hinged door on the left side covers the memory card socket. A door on the bottom of the body, adjacent to the tripod socket, covers the battery compartment.

The 18-to-55mm zoom lens that comes with the Digital Rebel package is fine for most purposes, but leaves something to be desired for astrophotography. The greatest single drawback to the lens -- indeed, to the camera itself -- is autofocus. It just doesn't work in dim light, especially when you are trying to focus on infinity. Aim the camera at the night sky, press the shutter button, and you can feel the camera's brain racking itself as it tries to figure out what to focus on.

It's easy enough to disengage autofocus simply by flipping a small switch on the side of the lens, and then turning the outermost portion of the lens to focus manually. But here comes another problem. First, since this is primarily an autofocus lens, there is no focusing scale on the lens itself. On a 35-mm camera, that would mean that you just turn the focus ring all the way in to set it at infinity, but that won't work here. Since the image sensor is very temperature sensitive, expanding and contracting as it goes, the lens is designed to focus past infinity. Between the coarseness of the manual adjustment and the fact that star images through the viewfinder are usually very dim (just a ground-glass screen -- nothing fancy), manual focusing is usually a process of trial and error. I've had the best success by first focusing on the Moon, a bright planet, or bright star before aiming at my intended target.

Of course, one great thing about a DSLR is that you can swap lenses. Using a universal camera adapter, such as that sold by Orion Telescopes, and a matching EOS T-ring, I can easily attach the Digital Rebel directly to a telescope. At the same time, I can match my old 400-mm telephoto to the Digital Rebel simply by replacing the T-ring that came with the lens (for an old Minolta) with a second EOS T-ring, and I'm ready to shoot.

Just how many images will fit on a memory card depends on two things: the card's capacity and the camera's resolution setting. The Digital Rebel has four resolution settings. Which you choose depends on what you want to do with the final image. RAW+JPEG offers the highest resolution, and should be selected if you plan on making huge enlargements. Large-fine is perfectly good for enlargements up to 8x10, or even 11x14. Medium-fine is acceptable for enlargements to about 5x7, while small is good for e-mailing images as well as for posting on the Web. The table opposite, from Canon, will give you some idea.

Resolution	Quality	Approx. file size	# images on 128MB card (not included)
RAW + JPEG 3072 x 2048	RAW + Medium/Fine	7.0 MB	16
Large 3072 x 2048	Fine	3.1 MB	38
	Normal	1.8 MB	65
Medium 2048 x 1360	Fine	1.8 MB	66
	Normal	1.2 MB	101
Small 1536 x 1024	Fine	1.4 MB	88
	Normal	900 KB	132

In the 11 months I've owned the camera, it has worked almost flawlessly, although I did have to return it to Canon once for repair. The problem was that the pop-up flash head wouldn't lock back down after firing. You should be able to push the flash head back down with your finger, where a small spring-loaded hook grabs it and holds it in place. Mine broke about 5 months into ownership. Canon repaired it under warranty and returned it quickly.

Okay, enough talk. How about some photos? Before we look at a gallery of my best, I must state up front that in no way do I consider myself an astrophotographer. What you see on the next page are a few crude attempts at capturing some aspects of the night sky electronically. Their quality only hints at what can be done with the Digital Rebel. To see what the camera can do in the hands of a skilled astrophotographer, check any of these web sites:
http://www.covingtoninnovations.com/dslr/EOS300Dastro.html
http://www.pbase.com/canon_300d/astro
http://www.u.arizona.edu/~jlacey/skyphoto.html

At the same time, Canon has a good on-line guide that details astrophotography with the Digital Rebel as well as its bigger brother, the 10D. Check:
http://web.canon.jp/Imaging/astro/index-e.html

So, in sum the Canon Digital Rebel is an exceptionally versatile camera that lets you couple to a variety of lenses as well as telescopes. Construction appears rugged despite its plastic body. For $1,000, it's tough to beat. True, it costs more than a conventional camera, but when you factor in how much money you'll be saving on film and processing, you might actually end up saving money in the long run.

Some Harrington Images Through the Canon Digital Rebel

Top Left: Total lunar eclipse montage: October 27, 2004. Digital Rebel coupled to my Vixen 4-inch f/10 refractor.

Bottom Left: Comet Maccholz and the Pleiades. Digital Rebel with standard lens zoomed to 85mm f/5.6 1-minute exposure at ISO 1600. Note the noise (graininess) in the image. ISO 400 and slower speed settings show very little noise, while noise at ISO 800 is low-to-moderate.

Above: Saturn, Jupiter, and Venus montage Digital Rebel taken with 25-mm Tele Vue Plössl and 2.5x Powermate through my 18-inch reflector.

Right: M42. Digital Rebel coupled to an old 400mm f/6.3 lens. 2-minute exposure at ISO 1600.

The author of seven books on astronomy, Phil Harrington regularly reviews astronomical equipment in *Astronomy* magazine. His book **Star Ware** reviews hundreds of telescopes, binoculars, eyepieces, and other accessories.Visit his web site, http://www.philharrington.net, for more information about his publications.

Thoughts about Astronomical Image Processing for Digital Cameras

By Tom Licha

The scope of this article

I gained all my experience in the field of digital image processing for astronomy by dealing with raw frames of 16 bit resolution of luminance per pixel coming from a specialized astronomy CCD cameras. These cameras typically do not have too many pixels. One million pixels is already regarded to be much. On the other hand a digital daylight camera like the Canon EOS 300D has more than 6 million pixels. But when saving the frames as JPG they will only have 8 bit of luminance resolution per pixel.

On the other hand, the image coming from an astronomical CCD camera is arriving at the PC totally raw and unchanged. This is not true for many digital daylight cameras.

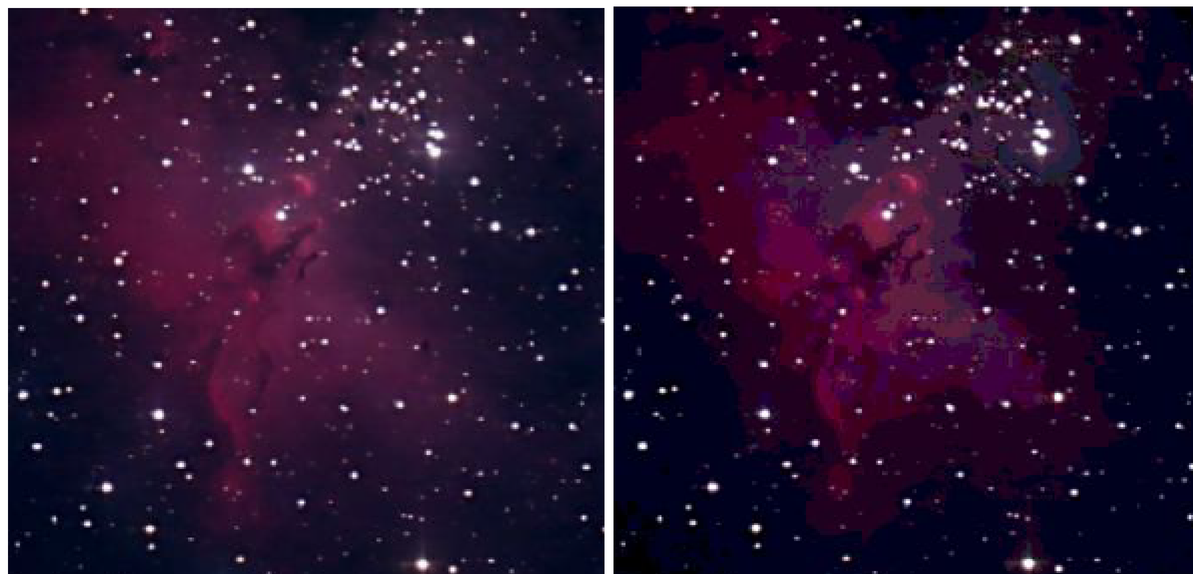
Another point is that the software for astronomical cameras is saving the files in FITS which is a lossless and uncompressed format that all the astronomy software packages can read. This is not the case for the uncompressed raw format of digital daylight cameras which differ from manufacturer to manufacturer.

These differences can cause the need for a different approach in image processing to get the best possible results.

Picking The 'Correct' Format For Storage

A good astronomical photo is one which is sharp and with as little noise as possible. This is usually achieved by using many exposures of the same object. These many frames must be selected, registered and then overlaid to give the resulting image with a better signal to noise ratio (SNR). Later on there is a big set of filters and treatments that will improve the image to show as much of a faint nebula or dim stars as possible.

This is not necessary for daylight photos. And that is the reason why the software bundled with the camera is not able to perform all theses tasks. Unfortunately, this software is usually the only one which is able to read the camera's specific raw frame format. That is why picking the lossless and high resolution raw format is not very appropriate for most digital cameras. However the JPG format can be used by many of the astronomical image processors. That is why I prefer that format for the Canon EOS 300D.



histogram stretch with 16 bit and 8 bit of luminance

Even the highest resolution of 3072 x 2048 in best JPG compression quality is downloading as fast as the 1300 x 1024 of the Starlight Xpress HX916 in uncompressed format. That is very convenient and not wasting valuable exposure time at the telescope.

Averaging Or Adding Of The Frames?

As we know from a television set, the luminance is responsible for the overall sharpness of the image. The luminance can be regarded as the number of levels of gray in an image. 8 bits is equal to 256 levels of gray which is about the maximum the eye can distinguish. That is why the JPG format has 8 bit of luminance (256 possible values of equal amounts of red / green / blue).

Unfortunately, with astronomical photos, there is the need to emphasize the darker parts of the image by histrogram stretching. Preferably, this is done in a logarithmic way and this will bring out the faint details of nebulae and faint stars. If you perform this on an 16 bit image there is no problem at all because there is as many as 65536 levels of gray. The difference between these levels of gray is so small, that even a stretch by factor 10 is still looking smooth to the human eye. Not so for 8 bit resolution! After the stretch you will clearly see 'steps' where there should be a smooth blending.

Averaging 16 bit frames is giving 16 bits at the end and that is just perfect for further processing. There is no practical difference in adding and averaging with 16 bit raw frames. But averaging 8 bit frames is giving 8 bits at the end and that is not enough. Therefore, we have to gain more bits of luminance and this can be done by adding the pictures instead of averaging them.

While 256 frames might look like a lot, it is normal for me to add from 25 to 100 frames. This results in 13 to 15 bits and considerably better than adding 1 to 4!

# of frames added	resolution in bit of luminance
1	8
2	9
4	10
8	11
16	12
32	13
64	14
128	15
256	16

Dark Frame Subtraction

There is only one reliable way of subtracting a dark frame from a raw frame to increase signal to noise ratio:

Take the dark frame at the same temperature, the same exposure time and then leave it completely unprocessed.

A digital camera has no controller to keep the temperature of the sensing chip constant. Though taking the dark frame immediately after each raw frame and using these pairs of raw/dark frames is a good estimation. But that means losing 50% of the possible exposure time and hence losing SNR!

Please refer to Thoughts about Image Calibration for low dark current, unregulated Amateur CCD Cameras to increase Signal-To-Noise Ratio for more detail.

But the killer for using dark frames with the Canon EOS 10D or Canon EOS 300D is the fact that these cameras use an undocumented noise reduction algorithm. Of course, they would also use this for the dark frame, not knowing that it shall be unprocessed to give reliable results.

Picking The 'Correct' Exposure Time And ISO Setting

A longer exposure time per frame means better SNR but not necessarily a better image! The first restriction for the longest possible exposure time is the quality of the guiding. This depends on the quality of the mount, the quality of the polar alignment (image rotation), the focal length of the optics (the smaller the longer the exposure), the resolution setting of the camera (the higher the shorter the exposure) and seeing effects of the atmosphere.

At my largest focal length of 1200 mm and the highest resolution I can usually expose for up to 300 seconds. My setup is restricted here by the differential flexure between imaging optics and guide scope. In case of bad seeing or very dim guide stars, I have decreased that to 60 or 120 seconds.

Now, for that maximum value I try to find the proper ISO setting of the camera so that the brightest part of the nebula, galaxy or the core of a cluster is not over exposed. The lower the ISO setting the lower the noise will be in that frame. In the case of the imaging optics having a focal ratio of f/4, my ISO settings vary from 200 to 1600 depending on the sky object.

That is - by the way - the reason why a beginner with less experience or a low quality mount should pick low focal lengths. With a fast 50 mm photo lens you can lower the ISO rate and at the same time expose longer to create very good photos. You just have to pick the larger sky objects.

Picking The 'Correct' Image Processing Settings Within The Camera

Digital cameras will process the images before storage. This is fine for daylight scenes but may not be for astronomical photos.

Sharpening is very noise sensitive and hence should be done as one of the last steps, definitely after adding

the single frames. Avoid any sharpening and try to set the camera to neutral or soft.

Contrast and color saturation is a different story. While these are not necessary for storage as raw files they can help a lot when saving as JPG. The reason is that the raw format (the camera's internal picture format) has more bits per color. That can be 12 or even 16 bit. When saving as JPG the camera has to decrease that and hence is affecting luminance and color saturation. Now, in astronomy with all these faint objects, the color saturation and contrast is very low anyway. Of course we want to 'keep' as much as possible when the camera is reducing the number of bits.

Andromeda Galaxy

"The Andromeda Nebula is a beautiful pinwheel of stars and luminous clouds of gas located beyond the Milky Way. An editor friend of mine once showed a picture of the galaxy to the art director of a magazine. 'That's gorgeous!' said the art director. 'But can we get a shot of it from another angle?'"

- Dennis Flanagan, American writer

Pluto Geeks

At the turn of the millennium, the Hayden Planetarium (at the Rose Center for Earth and Space) reclassified Pluto as a planetoid. Hayden director Neil deGrasse Tyson promptly received hate mail from dozens of people, including several children. "It became a New York thing," he later recalled. "We were accused of being 'mean' to Pluto." When Sedna was discovered some time later, Tyson wisely refused to comment on whether it was technically a planet or planetoid.

Alan Shepard: Moon Shot

"When Apollo 14 went to the moon, in 1971, it carried a rock-and-soil sampling tool that had a barrel grip and a cylindrical shaft three-quarters of an inch in diameter. Aluminum with Teflon O-rings, it was thirty-three inches long and consisted of six parts that could fit into one another to make the one shaft.

"Unbeknownst to NASA, the U.S. Navy astronaut Alan Shepard and a guy in the NASA machine shop took the head off a 6-iron and modified its hosel with a hexagonal fitting that would lock into one end of the sampler's handle. Shepard put the club head in a white athletic sock with two golf balls, concealed the package down one leg of his space suit, blasted off the big tee in Florida, and headed for the first at Lunarrama.

"After completing his duties up there, he assembled the golf club and pulled one of the balls out of the sock. Speaking on live television to the population of the planet he had left behind, and sounding just slightly like a barker in a sideshow, he said, 'In my left hand I have a little white pellet familiar to millions of Americans.' He said, 'I'm going to try a little sand-trap shot here,' and, like most golfers who routinely shoot bogey rounds, he offered an excuse beforehand: the space suit was inconveniently bulky - 'I can't do it with two hands.'

"He swung with one hand, four times. He whiffed. He nudged a ball a few feet. He shanked into a crater. And on his fourth swing he clocked one three hundred yards."

I thought, with the same clubhead speed, the ball's going to go at least six times as far," Shepard recalled. "There's absolutely no drag, so if you do happen to spin it, it won't slice or hook 'cause there's no atmosphere to make it turn..." The shot remained aloft for about thirty-five seconds (compared to six for a long drive on Earth). Shepard left the balls on the moon but brought the club back and later gave it to the USGA.

The Great Astronomers

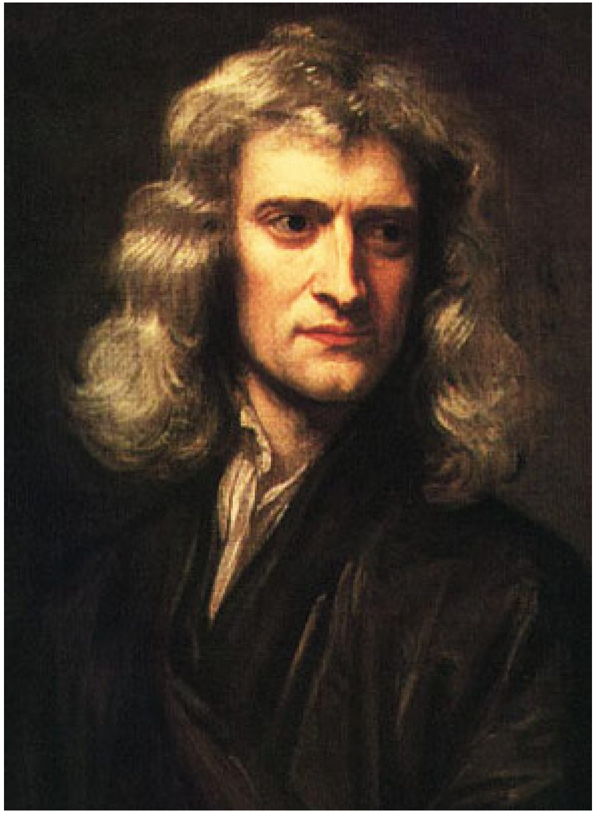
God said: "Let Newton bw! And all was light."
(Alexander Pope)

By Tim Carr

Galileo died in 1642, leaving behind a world which now seriously questioned the validity of the old view of the Universe as expounded by Aristotle and Ptolemy. The great Italian astronomer had dealt that old order a fatal blow with his discoveries. Now, it only remained for someone to bury its corpse.

Isaac Newton was born on Christmas Day, in the same year that Galileo died. His father had died before he was born, so he was raised by his mother who eventually remarried. When her second husband died, she brought her son back to the family farm in Lincolnshire, where the young Newton proved that wherever his future lay, it was not in farming. Luckily for us, he had an uncle at Trinity College, Cambridge, who recognised that his nephew had definite academic possibilities, and Newton enrolled in 1660.

It is important to note here that spotting the young man's potential was not perhaps as easy as one might think. Newton did not do *exceptionally well* at school, and in his early days at Cambridge, there was little to show the genius that would eventually become so obvious.



Godfrey Kneller's portrait of Isaac Newton (1689) oil on canvas.

Nevertheless, in 1665, Newton graduated without special distinction only to find his academic career brought to an abrupt halt. The plague had come to London, and he found himself back at the family farm. *The following couple of years would see some of the greatest advances in the history of science.*

Newton's insatiable curiosity led his thoughts into two main areas of research - motion and light.

Falling Apples

Sitting in his garden one day, he noticed an apple fall to the ground. (According to some accounts, it hit him on the head). He began to ask himself what force actually pulled the apple to the ground. He also began to ask himself what force kept the Moon in orbit around the Earth. With a great leap of imagination, Newton realised that the *same force* was acting in both cases.

This was a radical change to the established thinking of the day, which said (as did Aristotle), that there were two different types of motion, one on the Earth and one for celestial bodies. But being a great mathematician, Newton went much farther. He calculated that the

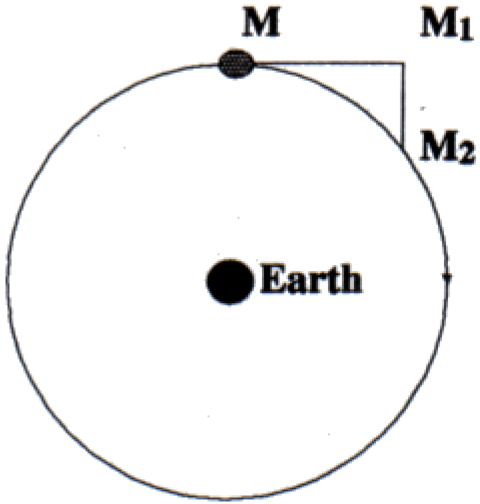
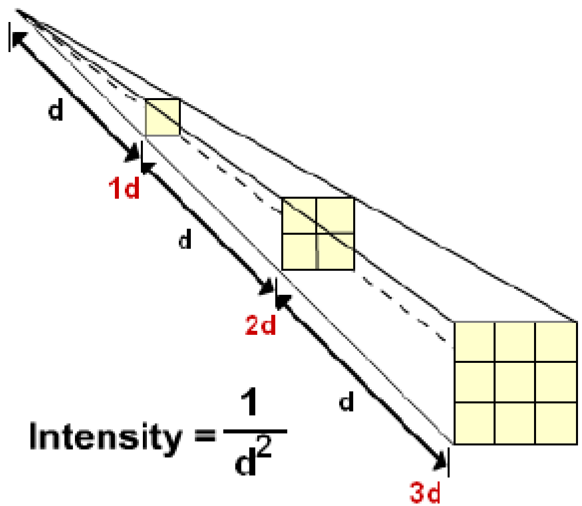


Fig.1: Movement of the Moon

Moon's motion around the Earth was a combination of it wanting to move in a straight line, but forever being pulled by Earth's gravity.

The Moon (fig. 1 - previous page) tries to move from M to M1, but instead it "falls" from M to position MZ. It continually falls towards Earth, but never actually gets any closer. The force Newton discovered obeyed strict mathematical laws. The famous ' Inverse Square Law' states that the further two objects are apart, the force acting between the is reduced by the square of their distance. When applied to satellites orbiting planets, this law means that the nearer a satellite is to a planet, the faster it will orbit around it, and the gravitational force between both bodies decreases according to the square of the distances between their centres. (In other words, if you double the distance between the two bodies, the gravitational pull between them is not half of what it was - *it is only a quarter*).



The Inverse Square Law

Light

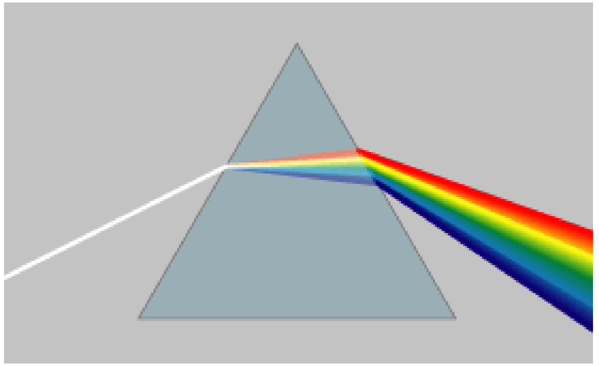
When Newton actually calculated the Moon's rate of fall, he found that his calculations were slightly out, so he left the problem aside for 15 years.

As well as motion, Newton also studied light in a way that no one had before. By allowing a narrow beam of sunlight to pass through a crack in his window shutters and through a glass prism, he found that the light spread out into a broad spectrum of different colours. Newton had discovered that white light was composed of light of different wavelengths, which, when combined, appear white.

Thinking that the colours might have been created inside the prism, Newton placed a second prism in the path of the rainbow of light. The coloured spectrum was changed back into a single narrow beam of white light. This was not simply a case of Newton amusing himself with colours. His discovery became the very foundation of the science of optics.

The reason the prism produced different colours of light is because the glass bends, or refracts light. Different wavelengths of light are refracted by different amounts, hence the separation of the colours.

Herein lay a serious problem for astronomers of the day. All telescopes were of the refractor-type, and like the prism, they focused the different wavelengths of fight to different points. The images were therefore not as sharp as might be expected, suffering from annoying colour fringes, (an effect known as chromatic aberration). Newton believed that there would never be a satisfactory solution to this problem as long as lenses



A prism breaking white light into its component colours

were used in telescopes, so he devised a new method of bringing the universe closer. (In fact, some years after his death, an extra lens was added to the refractor design, which largely corrected the chromatic aberration inherent in the early instruments).

The Reflector

Using a basic theory first proposed by James Gregory, a Scottish lens-maker, Newton made the world's first reflecting telescope. Instead of using a lens, a concave mirror, at the back of the telescope tube, reflected the light back up to a small flat mirror, which in turn reflected the light to an eyepiece at the side of the tube. One main advantage of the reflector was that all wavelengths of light were brought to the same focus, and as a result, images did not suffer from chromatic aberration. Another is that making a curved mirror is easier than grinding a lens. However, Newton may never have realised that since a mirror can be supported from behind, it is possible to make much larger reflectors than refractors.

In 1671, he presented his first reflector to the Royal Society, who duly elected him a member. The tele-

scope itself only had a mirror one inch in diameter, but today, thanks to Newton, we have reflectors one and even two *hundred* inches in diameter or larger.

Cambridge

His work on prisms and reflectors had, by now, made Newton famous. In 1667, he returned to Cambridge, where he would remain for the next thirty years. In 1669, the Lucasian Professor of Mathematics resigned in Newton's favour; so great had his reputation become.

Newton was not quite finished with light just yet. At the time, some scientists believed that light consisted of a wave, but Newton did not agree. After all, he reasoned, sound waves can travel around corners, but light can not. Therefore, light must be a stream of tiny particles. He developed a theory, based on his ideas of light, which was quite advanced for its time.

The climax of Newton's great career came in the 1680's. Robert Hooke, himself a great scientist and a bitter enemy of Newton, had told Edmund Halley and Christopher Wren that he had mastered the laws of heavenly motion. Halley was a friend of Newton, and when Wren (unimpressed by Hooke's boasting) offered a prize for anyone who could properly explain planetary motions, he took the problem to Newton. Halley is today, rightly remembered as the man who figured out that several different comets could actually be the same comet returning again and again, but his greatest achievement by far, was due to his friendship with Newton.

A replica of Isaac Newton's telescope of 1672. At 6 inches in diameter, it was also one of the largest telescope of its day.

Isaac Newton might have been one of the greatest scientists who ever lived, but as a person he left much to be desired. Cantankerous and childish when criticised, unwilling to defend himself publicly, he was happy to hide behind others who might defend him. Newton was not actually all that concerned about publishing his work on motion, and it was only with Halley's urging that he finally did so.

Newton had independently invented Calculus (as had Leibnitz in Germany), and using it he could calculate the paths of the planets with great accuracy. When Halley asked Newton: "If the inverse law be true, what will be the path of a planet?", Newton replied: "An ellipse". When his friend asked him just how he knew, he replied simply: "Why, I have calculated it".

To Halley's amazement, Newton had unlocked one of the keys to the universe, *but hadn't bothered to tell anyone.* Halley persuaded him to deliver a short paper on planetary motion to the Royal Society, and after a great deal of effort, got him to publish his works in book form.

It took Newton fifteen months to complete his great master-work, and even when it was finished, it nearly didn't get published. The Royal Society had run into financial difficulties. Again, Halley came to the rescue, paying for the publication himself.

`Philosophie Naturalis Principia Mathematica ' was published in 1687. It was recognised almost at once that this was *the* great work of science. In it, Newton brought together all his discoveries regarding motion and mathematics. It is impossible to adequately detail

its contents here, but at its heart are three laws of motion - three great insights into the nature of the universe.

Newton's Laws of Motion

The first law stated that a body remains at rest, or moves with uniform velocity, unless acted upon by an outside force.

The second stated that the acceleration of a body is directly proportional to the force acting upon it, and happens in the same direction as the force applied.

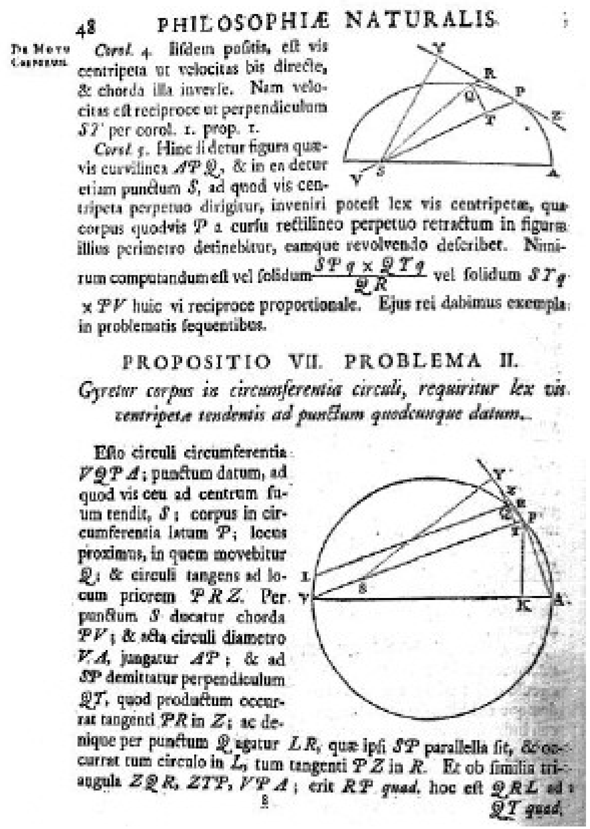
The third, and perhaps most well known, law stated that for every action, there is an equal and opposite reaction.

At last, here was conclusive proof of the theories which [Copernicus](#) had believed in, which [Kepler](#) had codified and which [Galileo](#) had formulated. Much else was explained, including the precession of the equinoxes, and the causes of the tides. However, the greatest astronomical significance of the Principia was that, for the first time, the *cause* of planetary movement was at hand.

Gravity is the force that keeps us orbiting around the Sun. The same force pulls apples to the ground. For almost two millennia, Aristotle and Ptolemy had dominated the study of the heavens, but now, at last, even the most reactionary of die-hards had to admit that in Newton, the world had found an intellect that was at least as great as any that had existed before.

Conclusion

Newton is regarded as a great astronomer because he clearly explained that gravity holds the planets in orbit around the Sun, thereby showing us the mechanism by



48 PHILOSOPHIÆ NATURALIS

De Motu Corporum

Corol. 4. Iisdem positis, est vis centripeta ut velocitas bis directe, & chorda illa inverse. Nam velocitas est reciproce ut perpendiculum *SY* per corol. 1. prop. 1.

Corol. 5. Hinc si detur figura quævis curvilinea *APQ*, & in ea detur etiam punctum *S*, ad quod vis centripeta perpetuo dirigitur, inveniri potest lex vis centripetæ, qua corpus quodvis *P* a cursu rectilineo perpetuo retractum in figuræ illius perimetro detinebitur, eamque revolvendo describet. Nimirum computandum est vel solidum $\frac{SPq \times QTq}{QR}$ vel solidum $STq \times PV$ huic vi reciproce proportionale. Ejus rei dabimus exempla in problematis sequentibus.

PROPOSITIO VII. PROBLEMA II.

Gyretur corpus in circumferentia circuli, requiritur lex vis centripetæ tendentis ad punctum quodcunque datum.

Esto circuli circumferentia *VQPA*; punctum datum, ad quod vis ceu ad centrum suum tendit, *S*; corpus in circumferentia latum *P*; locus proximus, in quem movebitur *Q*; & circuli tangens ad locum priorem *PRZ*. Per punctum *S* ducatur chorda *PV*; & acta circuli diametro *VA*, jungatur *AP*; & ad *SP* demittatur perpendiculum *QT*, quod productum occurrat tangenti *PR* in *Z*; ac denique per punctum *Q* agatur *LR*, quæ ipsi *SP* parallela sit, & occurrat tum circulo in *L*, tum tangenti *PZ* in *R*. Et ob similia triangula *ZQR*, *ZTP*, *VPA*; erit *RP quad.* hoc est *QRL* ad *QT quad.*

G

A page from the 1726 edition of the Principia.

which the universe works. He provided science with the tools to study and predict the motions of the planets with great accuracy. (When the [ESA Giotto spacecraft](#) was to rendezvous with [Comet Halley](#) in 1986, it used the third law to get off the ground - gases expelled from the engines pushed the rocket and spacecraft in the opposite direction - off the ground and into space, using Newton's mathematics to predict its orbit). Newton opened up the study of light, which allows us, today, to determine and analyse the compositions of far off stars and galaxies, and our own Sun. The development of the reflector now allows us to reach farther and further into space.

Most of all, Newton was a great scientist because he brought scientific thought forward by a quantum jump. The old ways were gone forever, and science was free to find its own way.

Until Einstein's time, Newton's view of a finite universe held sway. We now know that the universe is far more complex than Newton imagined, but it was his physics which started us on the road to an understanding of that universe.

Unlike others profiled in this series, Newton was greatly honoured in his own lifetime. He was knighted, and in 1689 became [Master on the Mint](#). He continued to work, even though he suffered a breakdown in 1692. When he died, in 1727, his body was interred in [Westminster Abbey](#).

Had you known him, you probably would not have liked him, but you could not have failed to admire his work.

Shoulders of Giants

Every schoolboy (and schoolgirl) knows of Sir Isaac Newton's famous remark that "if I have seen further [than others] it is by standing on the shoulders of giants." Fewer know that Newton's apparent humility may have been larded with sarcasm. The remark appears in a letter (dated 1675) to Robert Hooke, who had been critical of Newton's work. It seems likely that Sir Isaac was taking a swipe at Hooke's diminutive stature.

Master of the Mint

"The popular idea of mathematics is that it is largely concerned with calculations. What many people don't realize - and mathematicians at parties have given up correcting them - is that mathematicians are often no better calculators, and sometimes worse, than the average non-mathematician...

"Even the giants of mathematics suffer from this minor disability: 'Sir Isaac Newton,' said one observer, 'though so deep in algebra and fluxions, could not readily make up a common account; and, when he was Master of the Mint, used to get somebody else else to make up his accounts for him.'"

Wandering Mind

"One day [Isaac Newton] was sent to Grantham on business, a chore he always liked because he could drop in on his old friend the druggist, and spend the afternoon ogling the chemicals bottles.

"On his way home from town, he dismounted his horse so it could have a rest, and walked along leading it by its bridle. As always his mind wandered. Perhaps he was thinking about the four wheel carriage he'd just built or the system of shorthand he'd created or maybe he was just watching the sunlight on the grass and wondering what made the grass green.

"...miles and hours later he arrived at home not even aware that the horse had long ago slipped out of its bridle and he had walked the whole way back, alone."

Further Reading

[The First Book of Optiks](#)
[Excerpts from Newton's *Principia*](#)
[The Universal Law of Gravitation](#)
[Online *Principia Mathematica (Latin)*](#)
[Principia Mathematica (Amazon)](#)
[Opticks: Or a Treatise of the Reflections (Amazon)](#)
[Isaac Newton: The Last Sorcerer (Amazon)](#)

Submissions

We're looking for submissions for the next and future issues, whatever part of the world you live in.

The first four issues should give you a flavor for the kind of articles we're looking for. Tell us about any astronomical trips you've been on, whether they're to local or national Star Parties or vacations based around an astronomical event such as a solar eclipse. Give us warts-and -all reviews of equipment you own, from a lowly pair of binoculars, to eyepieces to large expensive telescopes. Let us know what you think of recent books on astronomy or your appraisals of astronomy software, whether they're freeware, shareware or commercial applications; profile your club or society; tell us about any equipment you've built or modified; tell us about your experiences with astrophotography and send us some of your results. We will be paying for any material used in future issues.

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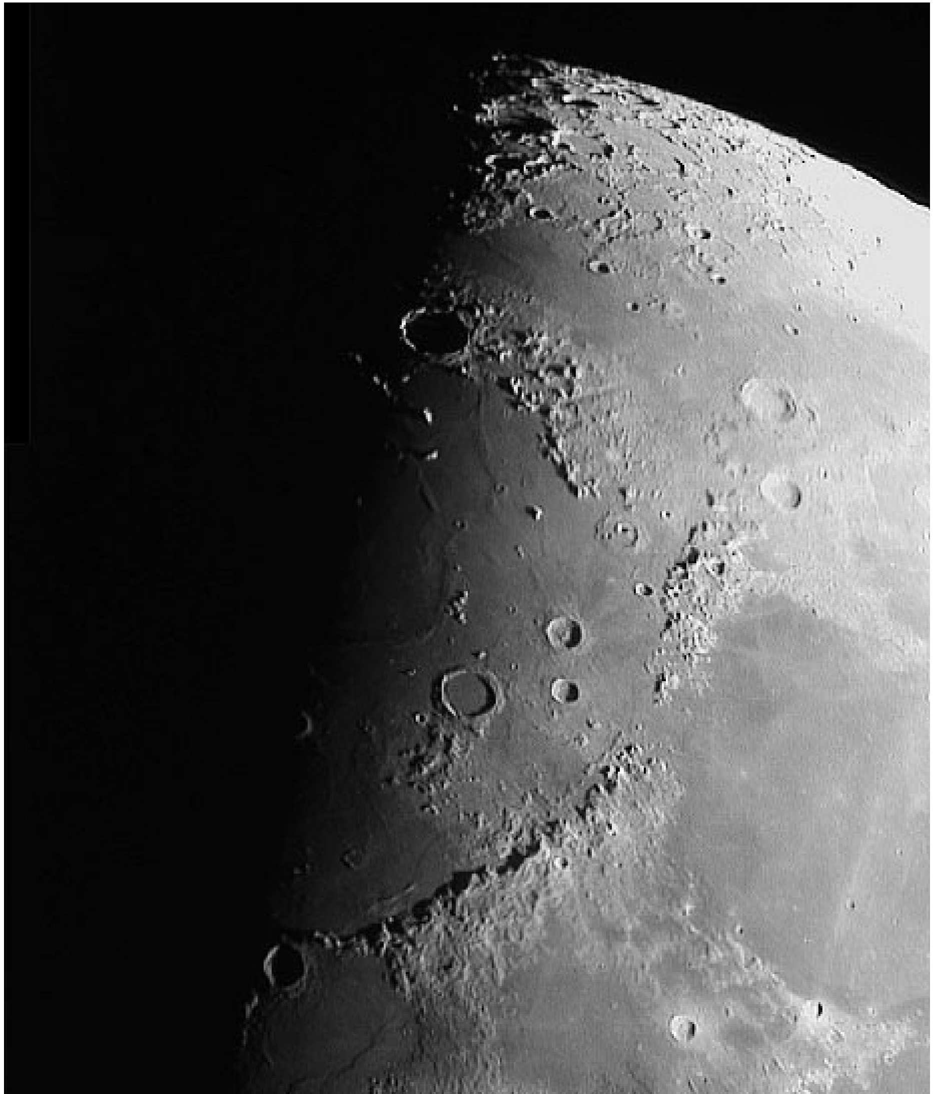
Showcase

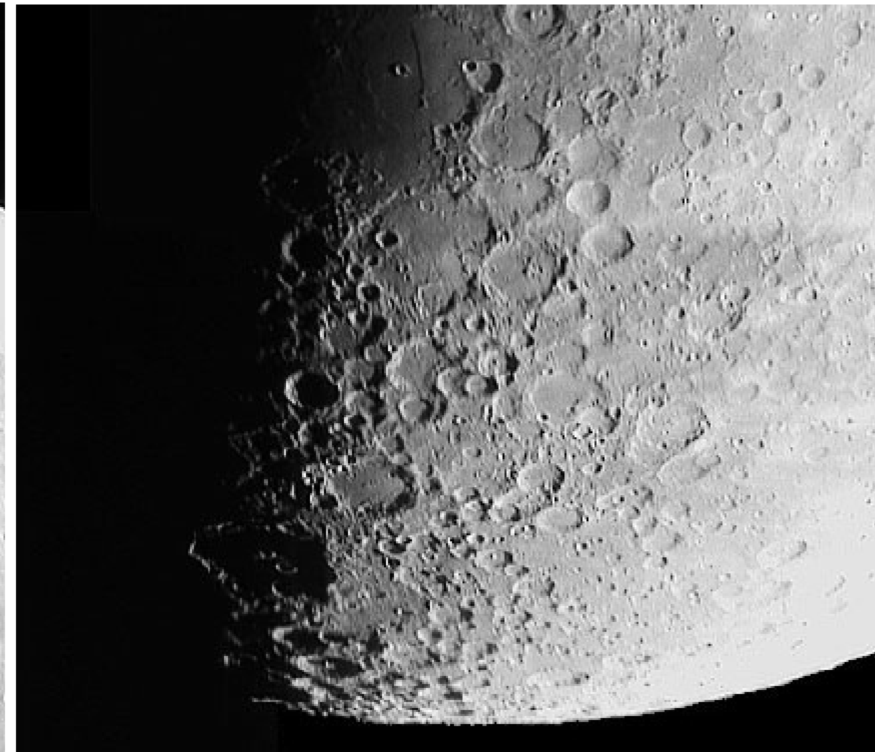
If you have images/photos, please consider sending them in.

Before I knew what one was, I took a few photos of a sundog recently. I thought it was brilliant and wanted to share it with others. When I learned of what it was, it didn't seem so great anymore, but the photo is going to remain a favorite of mine.

Cover Picture: The Moon (17days 1hour old - just past full): The terminator cuts through Mare Crisium (large rimmed basin at bottom left) with the edges of craters Picard and Pierce A/B just being visible inside the rim. To the right is Mare Serenatatis with Posidonius A just below centre in th image. The single prominent crater in Mare Serenitatis is Bessel which is only 19km in diameter. The two prominent craters in from the edge at the top of the image are Hercules and Atlas

Prime focus image through a Vixen VC200L 8" reflector at f/9 using a Starlight Xpress MX516 CCD camera. Mosaic of four 0.1 second images. Scope was stopped down (two holes in a 3-hole Hartmann mask were closed off). No dark frames or flat fielding applied. Final mosaic processed using the Unsharp Mask and High Pass FFT filters in Astroart 2.0. Final tweaking with adjustments to brightness/contrast.





Two lunar terminator images I took in Feb. 20, 2002. The images were taken at prime focus through a Vixen VC200L 8" reflector at f/6.4 (using a focal reducer) and a Starlight Xpress MX516 CCD camera. Exposures: 0.01 sec.

Left: The large large circular area is Mare Imbrium. To the right of it is Mare Serenitatis. Crater Plato is just on the terminator above Mare Imbrium. Crater Eratosthenes lies on the southern edge of the basin.

Right: At left of middle, the crater with the bright rim is Tycho. Below that, with its floor in shadow is the large crater, Clavius.

 Click here for a full-sized image and here for an image with labels